INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

MARCH 1958

ONE DOLLAR FIFTY CENTS A COPY

DEEP WELLS INCREASE 28%

How Blue Are Those Memphis Blues? . . . D-20

Heads International Petroleum Exposition to be held in centennial year. A-8

MISSISSIPPIAN CHERT

Kay County, Oklahoma

Responds well to Sandfrac*. Typical treatment: 750 gals. refined oil per foot of pay, and 1½-2 lbs. sand per gal. Injection rate: 30 BPM. Petrojel* successful but use limited by lease crude storage cost. Excellent results with Riverfrac*, but water shortage limits its use here.

YATES

West Texas — New Mexico

In certain areas, such as Shafter Lake Field, Andrews County, Texas, Riverfrac has been successful in many wells after all other treatments had failed. Typical treatment this field: 35,000-40,000 gals. fresh water, 20,000 lbs. sand. Injection rate: above 25 BPM recommended.

"D" SAND

Denver — Julesburg, Colorado

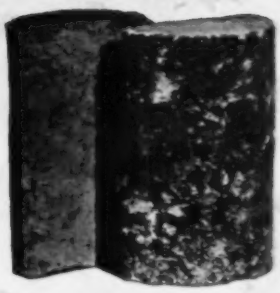
BHT frequently exceeds 225° F. Sandfrac, using refined oil, preceded by Mud Acid, generally used. Results vary widely, depending on degree of depletion. Typical treatment: 400 gals. Mud Acid, 10,000 gals. oil, 10,000 lbs. sand. Injection rates: 5-10 BPM through tubing, 10-20 BPM through casing.

LOWER FRIO

South Texas

Treatment of tight intervals depends mainly on depth and bottom hole temperature. Petrofrac* recommended for shallow wells with BHT under 150° F; Petrojel where BHT range is 150° F—180° F. In deep, high BHT wells, Stratafrac* or Acid Petrofrac* gives excellent results.

Dowell guide to fracturing



MISSISSIPPIAN CHAT

Barber County, Kansas

This formation, although only slightly soluble in acid; responds well to Acid Petrofrac. Typical treatment: 1,000 gals. fluid and 1,000 lbs. sand per foot of perforation. Injection rate: 30 BPM. Results on gas wells generally ten times drill stem test.

TENSLEEP

Big Horn Basin, Wyoming

Tight Pennsylvanian Sandstone, usually requiring high injection pressures. Normal treatment is down tubing. Widely varying depths and BHT. Petrojel successful in shallower sections where BHT is under 180° F; Sandfrac, using refined oil, preferred in deeper wells with higher BHT.

CARDIUM CONGLOMERATE AND SAND

Pembina Field, Alberta

Conglomerate interval normally prolific without stimulation. Sand usually requires fracturing. Sandfrac, preceded by Mud Acid, gets good results. Typical treatment: 500 gals. Mud Acid followed by 20,000-30,000 gals. lease crude with 40,000 lbs. sand. Injection rate: 20-30 BPM.

These cases give general information about treatments which have been successful in the formations shown. However, each well has its own unique characteristics which require the attention of experts. Dowell engineers have gathered performance data from fracturing operations in most active fields in the United States and Canada. Chances are that they already have the answer to your particular treating problem. If not, the Dowell laboratory and engineering staff is at your service. Dowell Incorporated, Tulsa 1, Oklahoma.

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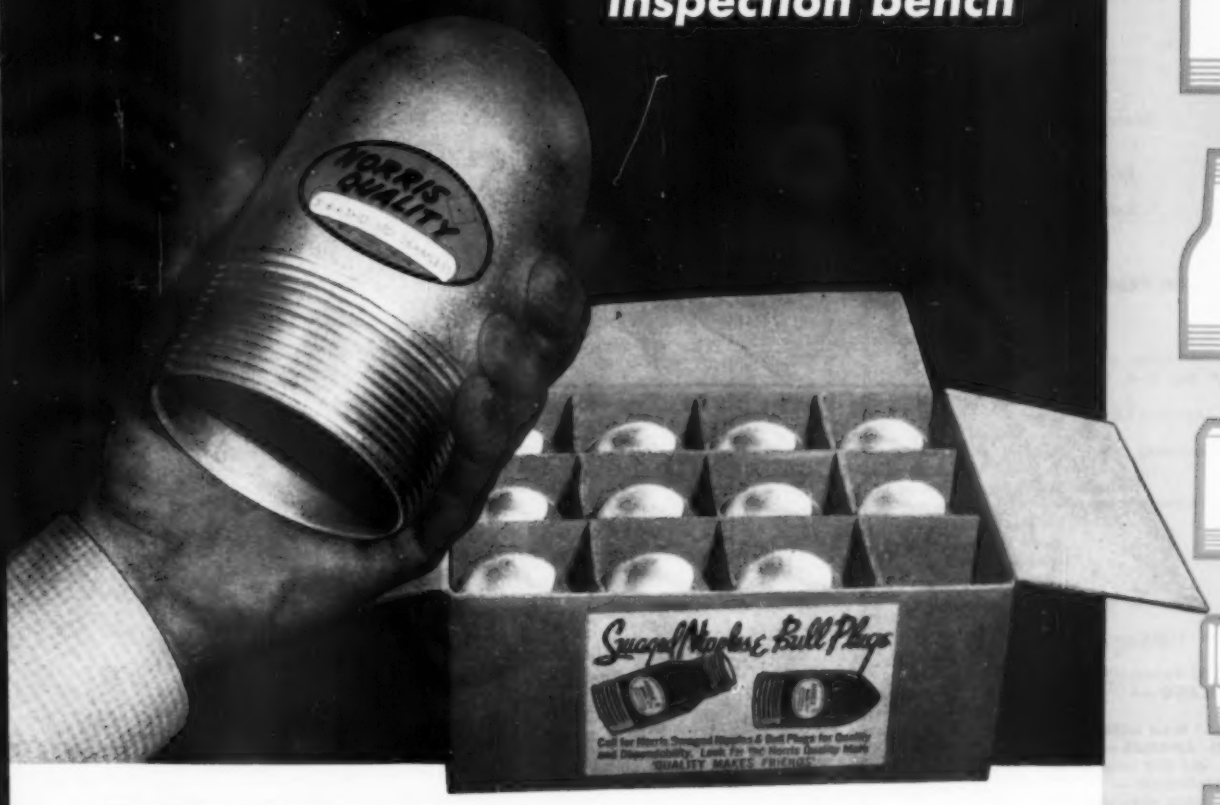

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the Petroleum Engineer

FOR MANAGEMENT

NUMBER 3 • VOLUME XXX • MARCH, 1958

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1797 - 1847 - 1854 - 1859 - 1865 - 1875 - 1886 - 1891 - 1901 - 1911 - 1929 - 1931 - 1959

PREPARE for ANNIVERSARY YEAR!

People often think of the petroleum industry as an upstart, a rash amoral roughneck with more money than sense. The picture is not true and never has been. Next year we celebrate the 100th Anniversary of our first oil well. Our traditions go back to much earlier times.

George Washington himself took a tract of land in Pennsylvania in 1748 on account of "the bituminous spring which it contains, of so inflammable a nature as to burn as freely as spirits."

There is a record of a storekeeper on the banks of the Allegheny River who wrote in his day book in 1797, "3 kegs Senica oil 50 Dllrs." At this time only 5 million people lived in the new United States of America. This Seneca oil the storekeeper stocked had one use — it was medicine for the sick, the lame and the blind. If you wanted rock oil you had to pay dearly, for the price figures out at $70 a barrel wholesale.

Fifty years later a man named Kier distilled some rock oil and ran off an illuminant better than any light existing in 1847, but supply was too limited for the 17 million citizens. Even if you could pay the $1.50 a gallon asked, carbon oil was hard to get.

A man named Bissel had the revolutionary idea of digging into the earth for petroleum and formed the first oil corporation. Colonel Drake was made its agent and he dug a well and found oil. For awhile crude oil cost $10 a barrel. Not yet could ordinary folk wander far from the fireplace to enjoy the light of a kerosine lamp.

Then a swarm of wildcatters jumped to California and others descended on the Mid-Continent states seeking petroleum. In the last quarter of the 19th century oil and gas lamps lighted a country from ocean to ocean. New lubricants greased the first trains that pushed across the thinly settled continent and oil the wheels of those new electric power stations.

Progress with petroleum gathered speed. We went from one use for petroleum in colonial times to thousands of uses today. The drills go below four miles. Chemists mix science with the magic earth oil to create new miracles of comfort and luxury and protection. Transmission lines carry oil and gas across the land quickly and cheaply. From 225,000 service stations a man can buy for 22 cents (plus taxes) a fuel for his car almost unknown — if not forbidden — to average people in other parts of this planet earth.

We have a fine tradition of service, of stewardship. We have sound reason to celebrate the 100th Anniversary of our modern industry.

Big plans are being made by organizations. The International Petroleum Exposition in Tulsa is scheduled for 1959. The Oil Information Committee has put new vigor into its public relations program, getting ready for the Anniversary Year. The industry has a thousand organizations — each one should contribute its own special talents to mark our Anniversary Year.

Every company needs to begin today — if it hasn't already — to develop a celebration of its own for 1959. A one-man firm could present a picture to the local art gallery or a large corporation could provide its dealers with air conditioning. The spirit of our Anniversary Year should reach every person in the industry and spread to every customer.

Whatever we do, let's make it interesting, ingenious, and useful — in keeping with the tradition of a great industry.

Ernestine Adams

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Thirty-eight 7A7 and twenty TC-12 "Oilwell" Pumping Units handle production on this flood. Inherent stability and accurate counter-balancing permit wide, safe speed range.

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Petroleum Profile

BILL WARREN had a big idea 35 years ago on which he built a thriving business. You only have to look at him to know he has enjoyed every hour of the building. He is also endowed with a bonus of confident energy that goes right on working outside business. His community, his church, and his industry benefit from this remarkable, dynamic personality.

You might not have been so sure he was headed straight for a top spot in business on March 15, 1922. But he did prove that day he had plenty of courage. At 24 years of age he opened his own office and became a specialist in natural gasoline, the only one in Tulsa, Oklahoma.

William Kelly Warren had arrived in Tulsa in 1916 from his native Nashville, Tennessee. He'd heard about the oil industry years before from a customer on his paper route. The idea of going west to seek his fortune appealed to the young man, who wanted to earn enough to get married.

He and Natalie Overall, who were childhood sweethearts, were engaged. While Bill learned all he could about the oil business, Natalie went to Vanderbilt University, where she graduated cum laude in 1920. They were married in 1921.

Young Warren's big idea was specializing in "casinghead" or natural gasoline. Tulsa was an oil boom town but no one confined his activities to natural gasoline. Warren had worked for Gulf Oil Corporation and Margay Oil Corporation and he was with McMann Oil and Gas Company when he resigned to open his new office in the Atco Building. His bride helped him with paper work. Then she accepted a teaching job at $6 a day that helped even more.

It wasn't long before the Warren Petroleum Company was doing all right. The owner pushed sales past the red ink line and went right on expanding business. He organized other companies for producing and processing, merging them into Warren Petroleum Corporation in 1937.

The small one-office marketing firm grew up. In 1955 it sold more than $100 million in products, 80 percent of it in natural gasoline and liquefied petroleum gas products.

The company was acquired by Gulf through an exchange of common stock in 1956. Mr. Warren remained as chairman of the board and chief executive officer, positions he has held since 1952. He became a director of Gulf Oil Corporation.

WILLIAM KELLY WARREN

Chairman of the Board

Warren Petroleum Corporation

Mr. Warren has so many honors and helps with so many industry, civic, religious and educational affairs that just a listing is impressive. We can only hit the high spots. He has worked in American Petroleum Institute, National Petroleum Council, Mid-Continent Oil and Gas Association, Natural Gasoline Association of America. He has received the Hanlon Award, highest honor of the natural gasoline industry. Recently he was elected president of International Petroleum Exposition to be held in 1959 in Tulsa. This is an important post both from industry and civic views. The 1959 Exposition will mark the centennial of the U. S. oil industry.

He is a director of the First National Bank and Trust Company of Tulsa and of Missouri-Kansas-Texas Railway.

On the educational side he is a member of the College of Commerce Advisory Council of the University of Notre Dame, a trustee of University of Tulsa, board chairman of St. John's Vianney Training School. He is a trustee of St. Francis Hospital, founded by William K. Warren Foundation. These are only a few of the organizations he finds worthwhile. He has demonstrated in his contributions of time and effort that the more you give, the more you have.

He holds an honorary Doctor of Laws degree awarded by Notre Dame and a Doctor of Science degree awarded by the University of Tulsa.

A lay leader in the Roman Catholic Church, Mr. Warren is Knight of the Holy Sepulchre and a holder of the Grand Cross.

Mr. and Mrs. Warren have six daughters and one son, all married. There are 15 grandchildren. The Warren homes in Tulsa and in LaJolla, California, are centers of hospitality. Despite his full life as businessman and humanitarian, he always takes time for family and friends.

C. E. Williams, Gulf Sales Engineer, Midland, Texas, and G. W. Ramsey, Assistant Plant Superintendent, inspect force feed lubricators on one of the modern gas engines at the Goldsmith plant of El Paso Natural Gas Company.

No lubrication problems in 8 years of operation

Since 1949, twenty-seven gas engine-compressor units developing 39,985 horsepower at the Goldsmith plant of El Paso Natural Gas Company have been thriving on Gulf Security Oil. Bearing, ring and cylinder wear maintenance records have been excellent.

Insure safe, more effective lubrication protection for *your* compressor units. Specify Gulf Security . . . the high quality, straight mineral oil. For full information, call your nearest Gulf office.

GULF®

GULF OIL CORPORATION, Dept. DM, Gulf Building, Pittsburgh 30, Pa.

THE CONFERENCE TABLE

Nothing is so fallacious as facts, except figures... GEORGE CANNING

IRS Is Watching You

Throwing the company's money around is sometime the only satisfaction you get from taking a customer out. Now you can't even enjoy that doubtful pleasure.

Internal Revenue Service is watching you! You have to report how much expense money you got and how you spent it, with substantial proof in the form of receipts and cancelled checks.

Who knows what Internal Revenue Service will consider legitimate business expense? Not "miscellaneous" the old favorite, you may be sure!

Nearly every one comes out short on the expense account because it is time consuming to write down every small expense. This is going to make it much worse.

Your only consolation is that it will hit the luxury entertainment trade even harder than you. Who's going to spend his own money on all that foolishness?

How Young Do You Go?

In the public relations field there has been some difference of opinion on how far down in school we are expected to reach. On long-term objectives Oil Information Committee includes junior and senior high with a well developed program.

It has been suggested, especially by some whose children are in the lower grades, that the younger the better for teaching how the petroleum industry operates and why the free enterprise system provides for the consumer better than any other method.

One artist-author we know aims his business and industry books at a junior and senior high audience. Merritt Mauzey is more artist that writer. "Oilfield Boy" (Abelard-Schuman, Ltd., 404 Fourth Avenue, New York 16) is generously illustrated with Mr. Mauzey's famed black and white lithographs, which are found in museums all over the country.

The simple tale, which seems to be taken from actual incidents, takes the boy through adventures when his father works in the oilfields and later when he begins his career there.

This is a good way to reach the inquiring minds of youngsters — with a tale of a boy's experiences and what he learned.

Brainstorming Criticized

Until recently the only specific objection to "brainstorming" was that ideas produced by group sessions on solutions of problems were not selected and executed. An experimental study carried out at Yale University has turned up a more basic objection. Conclusion of the study was that volunteers working as a group did not do as well either in total number of ideas or in number of original and good ideas as volunteers working alone. The reasons seem to be that persons working in a group fell into the same line of thought and were actually not free of possible criticism, although that is one of the rules of brainstorming.

We have thought that a round robin letter of brainstorming would be fruitful. Some minds are not stimulated quickly by direct contact with ideas. They are more apt to turn up a gem after sleeping on the idea. This, of course, would be more of a gentle rain than a "storm."

Public Relations Workshop

There have been a number of speeches at industry meetings with good ideas on how to enlist public understanding of petroleum operations. Now oil women have got down to cases with a "how-to" workshop on relations with the public.

This first Public Relations Workshop (knowing the women, there are sure to be more) will be held in Dallas, Texas, April 26. There will be a session on mechanics of getting words in the press and another on current issues and where to go to learn the facts. Maybe the women have the right approach.

Petroleum Taxes Jump

Governments—Federal, state, and local—piled up nearly $6½ billion taxes from the petroleum industry in 1956. That is 7 percent of all taxes ($91.6 billion) collected by all levels of government.

The 1957 tax is going to be still higher.

The 1956 tax bill was equivalent to 78 percent of the total value of all crude oil produced in the U. S. A. and imported into the country during the year. It was equal to 50 percent of the wholesale value of petroleum products processed in the U. S. during the year.

Here is how taxes have gone up:

1946	$2,211,970,000
1948	3,363,304,000
1950	3,791,016,000
1952	4,703,401,000
1954	5,155,701,000
1956	6,431,154,000

Only Doctorates Declined

Number of engineering bachelors degrees awarded in the United States increased 18 percent in 1956-57 over the year before. Number of masters rose 10.8 percent. But doctorate degrees declined 2.3 percent in engineering.

Totaling all degrees, it is estimated bachelors rose 6.8 percent, masters 14.8 percent, doctorates 2.3 percent.

Engineering enrollment reached the highest level in history — 297,000 — an increase of 7.2 percent over last year. This compares with a 4.1 percent rise for all college enrollment.

Creativity in the Sciences

New York University has a new program that will interest many. This is a research program to investigate patterns of creativity in the sciences. The program will use an operational approach. First will be a series of seminar meetings to seek methods of dealing with creativity delineating creative research patterns. Subject of the first seminar is "The Role of Conjecture."

Another project will be a specialized reference library to collect all the literature pertinent to creativity in the sciences. Dr. Myron A. Coler, the director of the program, is the research scientist who supervised the Manhattan Project. Anyone interested can write to New York University, Division of General Education, Washington Square, New York City.

Revenues Higher in 1957 and Earnings Practically Unchanged

EARLY ESTIMATES of financial reports for 1957 show the petroleum industry with higher sales and about the same profits as in 1956.

In the last quarter sales were generally higher than in the previous year but earnings were off for most companies.

The industry was feeling the profit squeeze brought on by:

1. Over-production of crude oil as a result of all-out effort in the Suez crisis which increased domestic productive capacity in the Western Hemisphere and closed off Middle East flow. Only spectacular demand rise could have prevented unbalance when Middle East plunged into the market again.

2. Over-supply for oil products because (a) industrial slowing, (b) competition from natural gas, and (c) warm weather.

Prices of petroleum products eroded. Crude price paring followed. Cuts did not appreciably affect supply but shaved profits thinner than usual.

Out of 30 companies giving preliminary annual figures, 16 had lower earnings for 1957 and 14 had higher than 1956. Of those who estimated gross income only 3 companies fell below 1956.

The fourth quarter of 1957 holds up remarkably well with 1956 when closing of the Suez Canal expanded trade and increased income. Revenues more than held their own and at least a third of the companies reporting had higher earnings than in the last quarter of 1956.

With scare headlines and scare talk, it might be well to point out that these companies (see table) did make a profit. Overall earnings were about the same as the previous year but more production and products had to be sold to obtain it.

There is every reason to believe that U. S. domestic demand will go up this year although not as much as the average annual increase maintained since the 30's of 5 plus percent.

The problem never yet solved by the petroleum industry is how to contract as opposed to expanding. It performed an heroic task in supplying Europe during the Suez crisis but was unable to reduce the great flow after the supply was available from former resources. When the industry learns to reduce operations as efficiently as it expands, short term dips will not create the panic you glimpse now.

Management still has sufficient authority and surely has gained the skill to handle fluctuating conditions. It is more a matter of leaning against the economic trend than of making radical changes. Unless management itself can smooth the business curve to some extent, the government will increase its attempts, which may prove disastrous to private industry.

Without radical changes the long term outlook of the petroleum industry is excellent. But it will no more go up without a rest—or recession, whatever you want to call it—in the future than it has in the past.

Some results of the slow-up are long-term advantages. For many years Texas operators have been telling the state legislature they were paying more than their share of state taxes but oil and gas taxes continued to rise. Present reduction in output has shown what no argument could—that taxes have to be more widespread to support state government.

This year when all business is taking a breather, there are many things worse for the oil industry than a cutback. Have you ever thought what would happen politically if the petroleum industry went on increasing profits when other business was marking time or falling off?

The first quarter in 1958 will be down from the same period in 1957 when the industry was going all out to meet Europe's demand (and being accused of holding back). January promises to be better profitwise than December.

The year 1957 was a good year and overall 1958 will probably be as good. One of the factors that will influence the economic situation of 1958 is the element of confidence. Chase Manhatten Bank's "Business in Brief" says confidence was an underlying reason why recessions in 1949 and 1953-54 were moderate.

Lignum-Vitae Products released an editorial which pointed out that men who should know better are becoming Business Typhoid Marys, contaminated with Virus Panic and spreading gloom wherever they go.

"Economic Emotionalism" is the title conferred by The Wall Street Journal on the confusion and contradictions that occur when politicians take over economic discussions and clothe them in a semantics fog. Economic emotionalism is not confined to political circles.

You don't have to be a complete Pollyanna to view the future with confidence. States one publication not known for its optimism: 1959 will see new records in production and business activity, plentiful jobs and high incomes.

Early Estimates of Last Quarter and 1957 Annual Income

(Figures in $1000's)

Company	Gross		% of 56	Net		% of 56	Gross		% of 56	Net		% of 56
	1956	1957		1956	1957		1956	1957		1956	1957	
Ashland Oil[2]	78,741	76,914	98	4,250	3,575	84	286,489	318,421	111	14,234	15,544	109
Atlantic Refining	146,450	143,117	98	14,471	6,333	44	544,865	565,943	104	47,210	36,670	78
Bishop	747	593	79	130	105	81	2,821	2,544	90	438	267	61
Colorado O & G	—	—	—	—	—	—	29,382	36,000	122	2,682	2,600	96
Continental Oil	—	—	—	—	—	—	—	—	—	51,800	46,700	90
General Crude	—	—	—	—	—	—	12,841	13,786	107	3,094	3,135	101
Husky Oil	6,854	7,209	105	488	457	94	14,701[4]	15,878[4]	108	1,021[4]	1,415[4]	139
Hancock Oil	13,780	14,324	104	1,864	1,740	93	53,926	56,347	104	7,144	7,125	100
Kerr-McGee	—	—	—	—	—	—	48,091[4]	63,016[4]	131	2,713[4]	2,536[4]	93
Leonard Ref	—	—	—	—	—	—	41,601[5]	44,005[5]	106	1,909[5]	1,528[5]	80
Maracaibo Oil	572	525	92	149	124	83	2,253	2,235	99	562	938[6]	167
Monterey[7]	5,470	5,736	105	708	733	104	20,770	23,433	113	2,520	1,294	51
Midwest Oil	4,328	4,715	109	1,556	1,568	101	16,465	19,252	117	6,559	6,755	103
Ohio Oil	72,029	72 853	101	10,920	9,483	87	278,004	291,982	105	41,216	41,490	101
Phillips Pet	—	—	—	23,633	21,973	93	1,038,815	1,135,000	109	95,203	96,200	101
Pure Oil	—	—	—	10,350	8,163	80	—	—	—	36,560	34,310	94
Shell Oil	—	—	—	35,705	29,203	83	—	—	—	135,848	135,000	99
Signal O & G	16,900	22,738	135	3,648	3,766	103	61,903	75,736	122	10,694	13,053	12
Sinclair Oil	—	—	—	24,968	16,621	67	—	—	—	90,030	79,500	88
Socony Mobil	—	—	—	—	—	—	—	—	—	250,000	220,000	88
Standard Ohio	102,755	99,671	97	6,433	9,339	145	392,526	419,046	107	26,592	23,920	90
Standard Jersey	—	—	—	—	—	—	7,281,883	7,972,000	110	808,535	800,000	99
Sun Oil	200,457	186,905	93	16,363	8,478	52	733,823	778,719	106	56,160	47,492	85
Sunray Mid-Con	86,024	89,096	104	13,787	12,084	88	332,668	358,201	108	45,310	57,155	126
Texas Gulf Prod	—	—	—	1,418	1,434	101	—	—	—	5,658	6,398	113
Texas Pacific O & G	6,073	6,044	100	1,704	1,717	101	23,939	24,865	104	7,210	7,232	100
TXL Oil[3]	2,513	2,927	116	652	955	141	9,369	11,553	123	3,716	4,346	117
Union of Calif.	103,218	103,504	100	12,129	10,560	87	401,518	436,731	104	34,241	38,236	112
White Eagle Oil[2]	—	—	—	742	770	104	—	—	—	11,989	11,696	98
Wilcox Oil	2,032	1,565	77	93	214	230	8,611	8,403	98	783	891	114
Woodley Pet	1,670	1,941	116	692	744	108	6,026	7,559	125	2,233	3,290	147

1. Ending Dec. 31 unless otherwise indicated
2. Fiscal year ends Sept. 30
3. Fiscal year ends Nov. 30
4. For 6 months ending Dec. 31
5. For 9 months ending Dec. 31
6. Includes 408,106 capital gains on stock sale
7. Fiscal year ends Aug. 31.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Costs Rise for Proposed Roads

The interstate highway network planned by the federal government, scheduled for next 13 years, is to cost more and more. Construction of the 41,000 miles system of multi-lane highways was originally estimated to cost $27 billion; present estimate is about $37 billion. Pending proposals to expand the project would run the total cost to $45 billion — and the estimates are moving upward faster than construction. It is now being suggested that the program be spread out over a 16-year period.

Reserve Program Cited

Atlantic Refining Company has been cited by the Defense Department for its cooperation with the reserve program of the armed forces through the encouragement of its employees to participate in reserve activities. About 1100 Atlantic employees serve in various reserve components of the armed forces. The company grants military leave and pay differentials, as well as protecting seniority, insurance, and other benefits while employees are on active duty.

Petrofina to Acquire Atlas

American Petrofina will buy oil and gas holdings of Atlas Corporation, including all assets of Petro-Atlas and El Dorado Refining. There are about 11,000,000 bbl of oil reserves, 125 billion cu ft of gas reserves, 20,000-bbl-per-day refinery and some 500 marketing outlets. Atlas will receive payment in cash and in American Petrofina common stock and convertible debentures.

Early Birds for Tulsa Show

Housing accommodation applications are already being made by exhibitors and visitors planning to attend the 1959 International Petroleum Exposition, reports Anthony Keating of the IPE Housing Bureau. The office expects 25,000 to 30,000 visitors for the Tulsa event, for the period May 14-23, 1959. Processing visitors and exhibitor applications are underway.

Management, Listen!

Leadership and statesmanship will be necessary in explaining to employees that wage and salary increases must be based on increased productivity, says L. F. McCollum president, Continental Oil Company. McCollum spoke out for labor, stating that "a few crooks and thugs in the labor movement doesn't give us a license to condemn the whole labor movement." He suggested that management listen attentively to what employees have to say. "We should emphasize what we are for, rather than just what we are against . . . Employees are just as disturbed by the present world and domestic situation as are members of management."

Researchers Reject OCAW

Eligible workers at the Gulf Research & Development Company at Harmarville, Pennsylvania, have voted 553 to 131 against joining the Oil, Chemical and Atomic Workers International Union. Some 693 of the plants' 1500 workers were eligible for the NLRB election. OCAW represents 5000 of Gulf's 46,000 employees in the United States.

Court Overrules Kansas

A Kansas Corporation Commission order has been struck down by U. S. Supreme Court on grounds that it affected the price of natural gas moving in interstate commerce. Kansas recently set a 11-cent minimum value on gas produced in the Hugoton field. Cities Service Gas Company appealed and received quick action from the higher court, which ruled that only the FPC had jurisdiction over pricing of gas, beginning at the well head and moving in interstate commerce.

Depletion Allowance Boosters

Government agencies are giving a favorable nod to the depletion allowance, but primarily because of the urgings of iron ore, coal, shale oil and other mining groups. These groups are asking higher rates (coal has 10 percent, shale oil 5 percent) to permit additional exploration in those fields. Otto Gressens, chairman, National Coal Association's tax committee, in a recent tax hearing in Washington said, "Although coal competes directly with oil and gas, I want to make it perfectly clear that the bituminous coal mining industry makes no allegation that the 27½ percent for oil and gas is excessive."

Engineering Over-Emphasis?

Members of congress have been warned against over-emphasis on scientific education at the expense of other intellectual disciplines by Joseph Amann, president of Engineers and Scientists of America. He cautioned against "the degree of enthusiasm bordering on hysteria to educate more engineers and scientists which was ushered in by Soviet Sputniks." Amann told congressmen that "thousands" of engineers and scientists have been laid off in recent months, and declared that the problem is not one of shortage but of proper utilization of our engineering pool.

— Courtesy Ohio Oil Company

Ohio's Quarters Doubled

A new nine-story building now under construction will more than double office space in the Ohio Oil Company's general offices in Findlay, Ohio. Excavation and foundation work has begun for the building which will occupy a full quarter-block and provide 270,000 gross sq ft of space. Completion is scheduled for early in 1960. Coupled with a recently completed addition on another of Ohio Oil's general office buildings, the construction program will increase office space 320,000 sq ft.

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*

*PEERLESS SPHERICAL
DUST and LIQUID SCRUBBER
FOR GAS PIPELINES

(A) The majority of incoming liquid and solid particles are directed down into reservoir. 1

(B) Lighter solid particles carried by gas stream are separated on surfaces of contactor which are kept wet and clean by revolving thru liquid reservoir. 2

(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet. 3

- **The dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes **wetted surfaces** for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

PEERLESS MFG. CO. DALLAS TEXAS

PEERLESS MANUFACTURING CO.

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Representatives in All Principal Cities

Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

Hardly Allowable!

Lowest oil producing schedule in Texas for eight years has been issued by the Railroad Commission by request of both major companies and independent producers. The commission set a nine-day rate for Texas' prorated wells for the month of March. The unprecedented action was made in an effort to lessen excessive crude stocks in the state. The allowable order will permit a daily flow of 2,517,249 bbl. Some independents suggested a proration as low as seven days per month. To sum up feelings expressed by the Texans seeking to steady the bloated market, Alwyn P. King, a Houston independent producer, said: "If we are going broke, let's all go broke together."

Pan American Looks East

Pan American International Oil Company is the new subsidiary of Pan American Petroleum Corporation. It will administer oil exploration and development operations in the Eastern Hemisphere. Principal offices are in New York City under supervision of its new president and director, C. F. Dohm, formerly president of Conorada Petroleum Corporation. At least one branch office is to be established in Europe. Pan American International then becomes a subsidiary of a wholly owned subsidiary of Standard Oil of Indiana.

Keeping It Back on the Farm

Independent producers' plight in this day of domestic crude surpluses is well expressed in a request by Trice Production Company to the Houston (Texas) City Council. The company has asked for a delay in drilling a second well on the Houston prison farm because it can't sell 2500 bbl of oil from the first well. Under existing drilling commitment with the city, Trice had agreed to drill the second well within 90 days. The company, unable to market the oil, is running out of storage.

Military Oil Purchases Hit

Most foreign and domestic operating U. S. oil companies are agreed on one thing: Large military purchases of foreign jet fuel are completely inconsistent with the government's program to restrict importation of crude. Some importing companies insist that they will bolt the voluntary program unless the practice halts. Producers associations have struck out verbally against such foreign oil buying as detrimental to our "Buy American" program. West Coast producers and refiners are expressing serious concern. Board Chairman Reese Taylor of Union Oil Company of California wired Secretary of Commerce Sinclair Weeks to urge "That President's oil imports committee decide against any awards to Caribbean suppliers."

Foster to New IOCC Post

Earl Foster

Lawrence R. Alley

Earl Foster, executive secretary of the Interstate Oil Compact Commission since 1944, has resigned that position to accept the office of general council of the group. In this capacity, Foster will be responsible for keeping the 28 member states advised of litigation and legal activities affecting the various conservation programs. Lawrence R. Alley, who has served as assistant secretary for the past nine years, has been selected to serve as acting executive secretary to fill the vacancy created by Foster.

Now It's Sinclair Venezuelan

Stockholders of Venezuelan Petroleum Company, subsidiary of Sinclair Oil Corporation, have approved changes in the company's name to Sinclair Venezuelan Oil Company. Sinclair Venezuelan now produces about 50,000 net bbl of crude oil daily and processes about 20,000 bbl daily at its refinery at Puerto La Cruz. Sinclair Oil owns more than 96 percent of Sinclair Venezuelan Oil.

Seven National Crimes

1. I don't think.
2. I don't know.
3. I don't care.
4. I am too busy.
5. I "leave well enough alone."
6. I have no time to read and find out.
7. I am not interested.

Humble Retirement Eased

Humble Oil & Refining Company has liberalized its retirement program for under-65 workers. It is offering extra inducements to male employees over 55 who have 30 years of service and women employees over 55 who have accumulated 20 years of service. Although full pension annuities are still to be paid only at age 65, the new program yields a more generous pension than they would ordinarily get if they retired before 65.

"Detroit Case" Settled

Standard of Indiana has won its 17-year battle for "good faith" defense competition in a Supreme Court decision on the "Detroit case" arising out of the 1941 Robinson-Patman Act. The Court held that lower prices the company gave jobbers in Detroit were made in good faith to meet competition and was a defense action. Much confusion still surrounds the original act, and the decision may spark more active efforts by opponents of the decision for passage of the Kefauver-Patman amendment, which would nullify the Court's ruling.

Union Clarifies Agreement

Union of California seeks to clear up recent statements concerning its export and import agreement with Maruzen Oil of Japan. Maruzen has contracts to buy 2,800,000 bbl of California domestic heavy crude, diesel and fuel oil in 1958. In return, Union will buy 790,000 bbl of distillate in the same period. Union has not shut off any crude producer and is buying 1500 bbl per day of California oil that had been cancelled by others. It will soon be buying 10,000 to 12,000 bbl per day of oil from Four Corners pipeline.

Pattern for "Adjustment"

Jack A. Vickers, president, Vickers Petroleum, forecast a continuing adjustment for Mid-Continent portion of the oil industry. A better balance between supply and demand of finished petroleum products is an absolute necessity, inferred Vickers, and proposed that the industry accept a three-point program: (1) Maintenance of tight controls on allowables, (2) continuance of pledged, self-imposed import quotas, (3) voluntary cutbacks in refinery runs.

Good Wells Make Good News

A Monthly Report Of Successful Well Treatments

March, 1958

For sustained production increases from many formations, fracturing is often recommended over any other stimulating technique. "Frac" sand provides a permanent propping action in formation fractures — to improve the drainage characteristics of the well. Here are some recent examples of what has been achieved with Dowell fracturing services.

- **Reagan County, West Texas.** (Old well) Production from this Spraberry well had declined to 15 bopd. Dowell recommended fracturing with Petrojel* to increase production. Treatment was performed using 60,000 gallons jelled crude and 90,000 pounds sand. Because the well was producing from three sets of perforations — 6583 to 6607, 7436 to 7460 and 7486 to 7492 — 275 ball sealers were used during treatment. Injection rate averaged 53 bpm at 1600 psi. *Well tested 100 bopd 33 days after treatment.*

- **Beaver County, Oklahoma.** (New gas well) This well was completed through perforations in the Hoover formation (4450 to 4484 feet). Duofrac* was recommended as the best fracturing service to bring in this well. Dowell fractured using 30,000 gallons three per cent acid carrying 1 pound sand per gallon. In this case a surface tension reducing agent and FLA* (Fluid Loss Additive) were also used. Injection rate averaged 55 bpm down casing. *Production increased from a show to 40 mmcfd.*

- **Hamilton County, Illinois.** (New well) Petrojel was used to fracture this well drilled in the Aux Vases. Casing was set and perforated from 3118 to 3148 feet, four shots per foot. Dowell fractured with 15,000 gallons jelled crude and 15,000 pounds sand at an average injection rate of 31 bpm. 35 ball sealers were injected midway through the treatment. *Well flowed 2030 barrels of oil during the first 20 hours it was opened, and levelled off at 1437 bopd after it cleaned up.*

- **San Juan County, New Mexico.** (New well) Completed in Mancos sand through perforations, 1130 to 1182 feet and 1222 to 1285 feet, this well tested 20 boph. Because of thick pay section, operator wanted to fracture and retest. Dowell recommended Sandfrac*, using 65,000 gallons lease crude and 65,000 pounds sand. Injection down 5½-inch casing averaged 76 bpm. 150 ball sealers were injected behind first 30,000 gallons fluid to divert remaining fluid into less permeable zones. After treatment, *well flowed 120 boph on a prolonged test.*

Dowell offers nine basic fracturing services and an infinite variety of modifications to meet the specific requirements of any well. For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service, or write Dowell Incorporated, Tulsa 1, Oklahoma.

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Meetings

Mar. 17-21—**National Assn. of Corrosion Engineers,** annual conf., Civic Auditorium, San Francisco, Calif.

Mar. 20-21—**AIME,** Petroleum Production and Reservoir Engineering conf., Mid-Continent local section, Mayo Hotel, Tulsa, Okla.

Mar. 24-26—**Midwest Gas Assn.** meeting, Broadmoor Hotel, Colorado Springs, Colo.

Mar. 24-26—**WPRA** annual meeting, Hilton Hotel, San Antonio, Tex.

Mar. 27-29—**AIME,** Pacific Southwest Conf., St. Francis Hotel, San Francisco, Calif.

Mar. 28-29—**AIME** Student Paper Contest, University of Oklahoma, Norman, Okla.

Mar. 29—**North Texas Oil and Gas Assn.,** annual meeting, Kemp Hotel, Wichita Falls, Tex.

Mar. 31-Apr. 2—**API Division of Transportation,** annual pipeline conf., Jung Hotel, New Orleans, La.

Apr. 1-3—**Corrosion Control,** short course, sponsored by the Oklahoma City chapter of National Assn. of Corrosion Engineers and the College of Engineering, University of Oklahoma, Norman, Okla.

Apr. 9-11—**API Division of Production,** Mid-Continent district meeting, Biltmore Hotel, Oklahoma City, Okla.

Apr. 12-17—**American Chemical Society,** 133rd national meeting, San Francisco, California, including **Pacific Chemical Exposition,** Civic Center, Exhibition Hall, San Francisco, Calif.

Apr. 14-17—**ASTM,** Design Engineering Conf., International Amphitheatre, Chicago, Ill.

Apr. 15-17—**Southwestern Gas Measurement short course,** University of Oklahoma, North Campus, Norman, Okla.

Apr. 16-18—**Natural Gasoline Assn. of America,** annual convention, Baker and Adolphus hotels, Dallas, Tex.

Apr. 17-18—**Fifth Annual West Texas Oil Lifting short course,** Texas Technological College, Lubbock, Tex.

Apr. 17-18—**Geophysical Society of Tulsa and Tulsa Geological Society,** annual Mid-western Exploration Meeting, Tulsa, Okla.

Apr. 17-18—**Society of Petroleum Engineers of AIME,** Louisiana, Arkansas, East Texas and Mississippi petroleum sections, gas technology symposium, Shreveport, La.

Apr. 18-20—**AIME,** 3rd annual conf., Alaska Section, University of Alaska, Fairbanks, Ala.

Apr. 20-23—**American Institute of Chemical Engineers,** regional meeting, Sheraton-Mt. Royal Hotel, Montreal, Can.

Apr. 20-24—**Scientific Apparatus Makers Assn.,** annual meeting, El Mirador Hotel, Palm Springs, Calif.

Apr. 21-23—**API Division of Production, Rocky Mountain district,** Cosmopolitan Hotel, Denver, Colo.

Apr. 27-29—**Independent Petroleum Assn. of America,** midyear meeting, Sherman Hotel, Chicago, Ill.

Apr. 27-30—**AAPG,** Rocky Mountain section, 8th annual meeting, Casper, Wyo.

Apr. 28-29—**Automatic Control in the Petroleum and Chemical Industries,** short course, sponsored by the School of Electrical Engineering, University of Oklahoma, Norman, Okla.

Apr. 29-May 1—**PIEA-PESA,** joint convention, Adolphus Hotel, Dallas, Tex.

May 5-6—**Society of Petroleum Engineers of AIME,** North Texas section, biennial secondary Recovery Symposium, Wichita Falls, Tex.

May 5-9—**API Safety and Fire Protection Committee,** midyear meeting, Cosmopolitan Hotel, Denver, Colo.

May 7-9—**API, Division of Production,** Eastern district, Deshler Hilton Hotel, Columbus, O.

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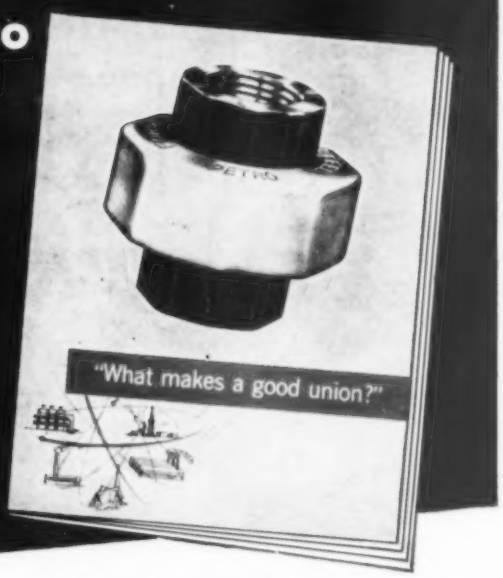

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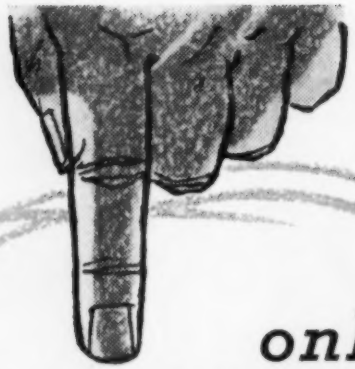

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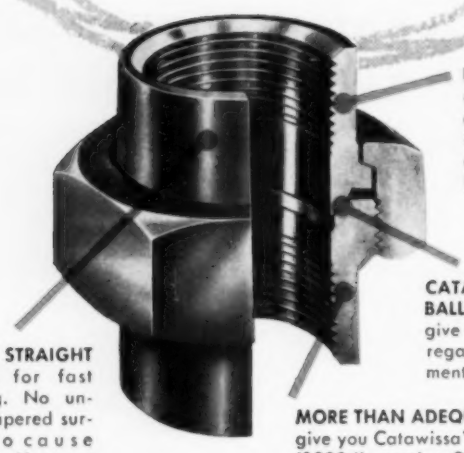
gives you all these features for your forged steel pipe union requirements



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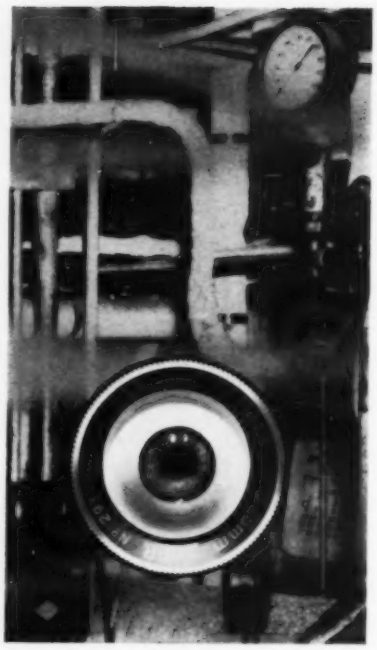

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Tubing stretch mill, Youngstown, Ohio. Electronically controlled mill to be completed during second quarter of 1958 . . . will provide increased production for Tubing comparable to our increased capacity for Casing. Both Upset Finishing Mill and this facility will greatly augment our existing No. 1 and No. 2 Seamless Mills in Youngstown. Photo shows mill building under construction.

NEW MILLS FOR BIGGER MARKETS

Two years ago, ground was broken for our three new seamless Pipe facilities. The express purpose of this massive expansion program was to make YOUNGSTOWN'S production capacity and seamless pipe product mix conform to the future needs of the Oil and Gas Industries. These seamless pipe facilities are now integrated with your demands. This means you can look to YOUNGSTOWN for a full line of Oil Country Tubular Goods without limitations as to size, grade or finish in Drill Pipe, Casing, Tubing and Line Pipe!

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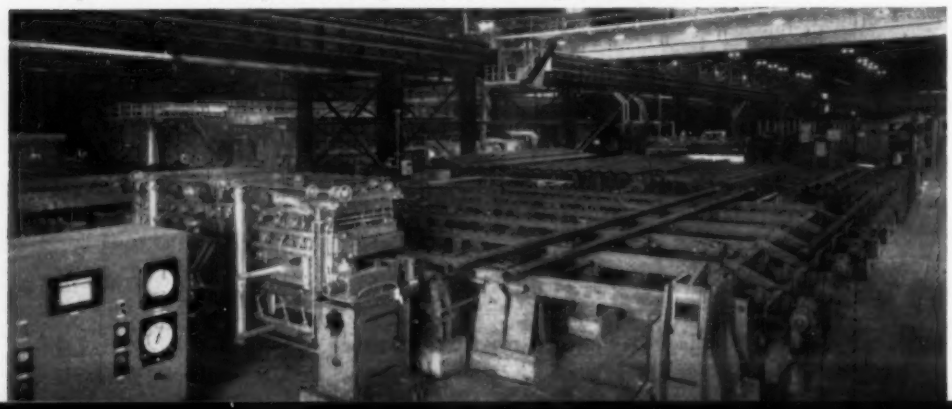
No. 3 seamless mill, Indiana Harbor, Indiana. Fully automated, ultra modern mill . . . began operating September 30. Contains world's largest Rotary Billet Heating Furnace . . . adds to our over-all capacity in both alloy and carbon casing. Offers API casing in sizes 4½", 5", 5½" and 7", in grades H-40, J-55, N-80, in ranges 2 and 3 . . . plus line pipe in sizes 4½", 5$\frac{9}{16}$" and 6$\frac{5}{8}$" O.D. in grades A, B, X-42, A106, A53 in single and double random lengths. Photo shows Rotary Furnace in foreground.

Upset finishing mill, Youngstown, Ohio. Also a fully automated mill began operations September 15. Contains a pair of automatic upsetters with attendant furnaces plus a full-length normalizing furnace for highest quality control of all products. This mill adds to our capacity for Drill Pipe in grades D, E, x-95 and in Upset Casing (Speedtite). Photo shows upsetter and control panel in foreground, normalizing furnace in left rear.



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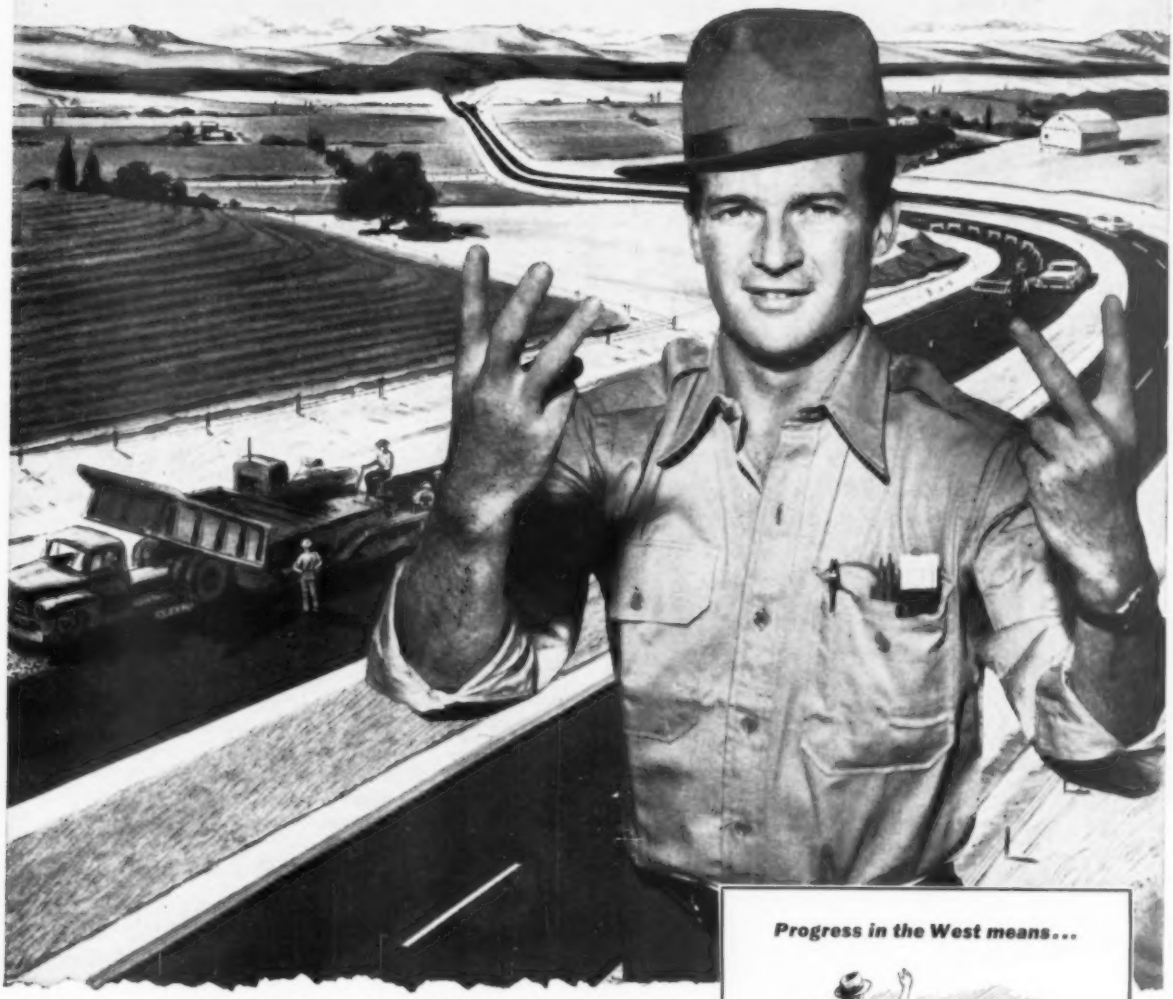

Asphalt can save billions of dollars on the 41,000 miles of superhighways the U.S. will build in the next 15 years

Heavy Duty Asphalt Costs 20% to 50% Less Than Other Pavements. This means extra miles of superhighways for your tax dollars . . . smoother, more enjoyable miles, too. Safe, skid-resistant asphalt cuts down headlight and sunlight glare, makes lane markers easy to see.

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STANDARD OIL COMPANY OF CALIFORNIA

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Take another look at this Koehring 205 Cruiser. It brings you the economy of one-man control for crane work-and-travel — *plus road speeds up to 21.5 m.p.h.* This way, one fast-moving Cruiser efficiently serves several widely-separated work-areas — travels 30, 40 miles or more to do a special lifting or material-handling job — and returns, all in the same day.

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Cruiser highway travel is unrestricted. Overall width is only 8 feet. Axle-load distribution meets street and highway regulations in most areas — even when carrying 25-foot folded boom. For all its speed and roadability, the 4-wheel-drive Cruiser has plenty of tractive power. It climbs 30% grades — is easy-handling, maneuverable on or off-pavement. Turns in 27½-foot radius — has power-steering, smooth torque-converter drive, big air-hydraulic brakes. One engine supplies all power for work and travel — one man controls all operations. Consider what this, alone, can mean in lower costs, and increased efficiency on your work.

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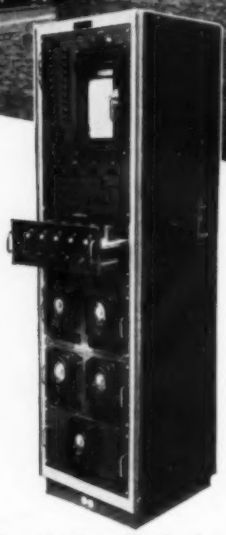

Canadian Seaboard Selects BS&B

Phanto-Matic

For Lease Production Automation

With BS&B, Ltd's completion of this installation in the Pembina Field near Drayton Valley, Alberta, the Canadian Seaboard Oil Company, of Calgary, became the first producing company in Canada to achieve *full lease automation* with a BS&B PHANTO-MATIC Lease System.

The PHANTO-PUMPER unit, housed in the partially completed building at left in the picture above, automatically handles the production from four wells which are connected to the production header assembly. It is here that wells are individually switched from production to test and data recorded on a strip chart, then switched back to production again. Also included in this unit are production and test separators.

From these separators the oil goes to a 300 bbl. surge tank (at right in the picture), and then to the 25 bbl. PHANTO-GAGER (center) which does the actual measuring of the oil to the pipeline. Both the PHANTO-PUMPER and the PHANTO-GAGER are skid-mounted units and are electro-pneumatically controlled. Illustration at right shows the PHANTO-PUMPER controls console.

Auxiliary equipment includes a standby generator which is automatically started in case of power failure to the lease, an air compressor to supply air to the pneumatically operated valves and a 3-pass indirect heater to heat oil going to the two separators and through the surge tank.

BS&B PHANTO-MATIC Lease Systems are available for handling lease production ranging from only a few wells up to a hundred or more, and may be purchased either as completely integrated systems or in component parts to supplement existing equipment. Ask your BS&B Man—or write for full information to . . .

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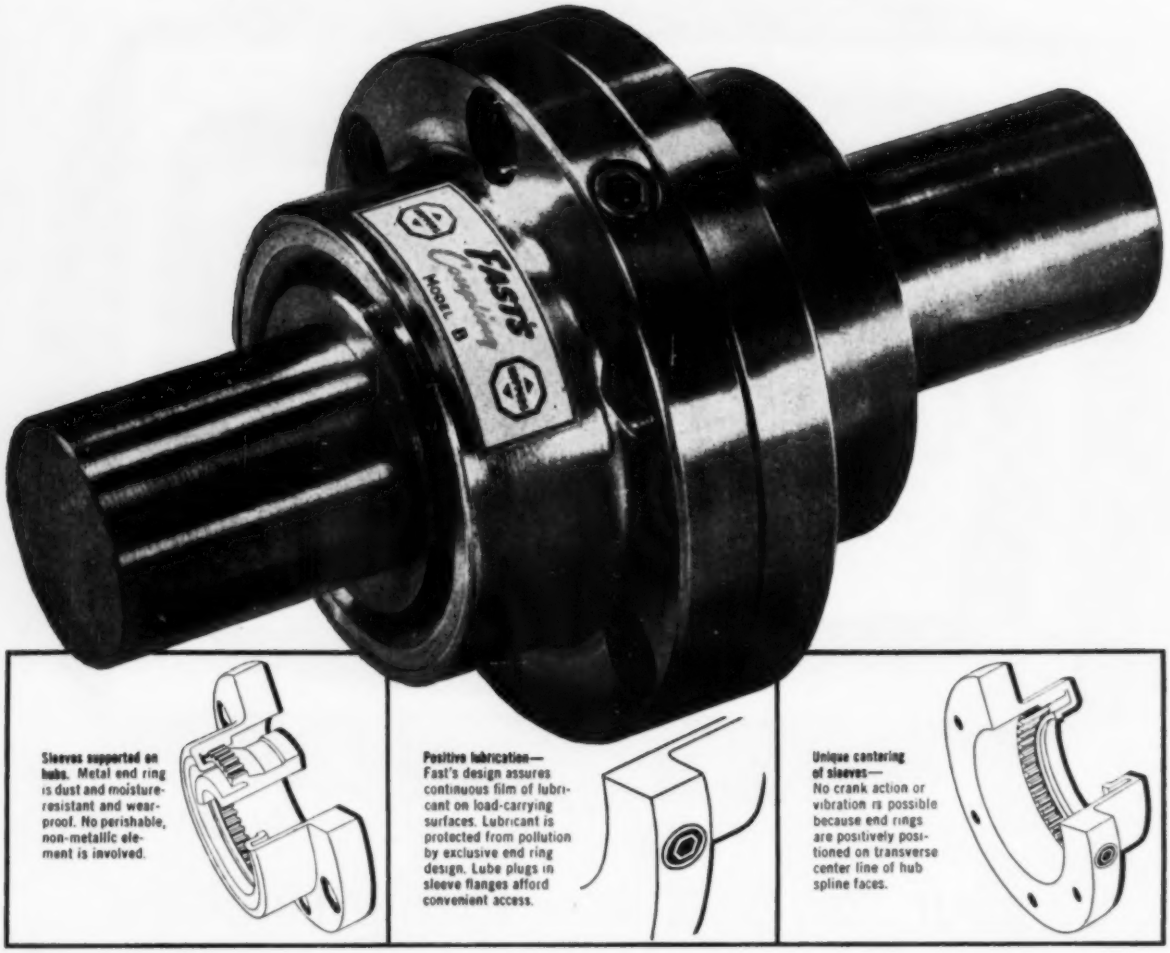
We invite your inquiries on Catforming. Write or wire The Atlantic Refining Company, Research and Development Dept., P.O. Box 8138, Philadelphia 1, Pa.

ATLANTIC

it's the CATALYST that counts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Fast's Model B coupling reduces downtime and upkeep for light-to-medium drives

Mechanical flexibility eliminates costly shutdowns and expensive shaft replacements. But—it's only one of many cost-saving features.

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The Model B coupling gives you the same features that have made Fast's the world's leading coupling for over 35 years. You get the same trouble-free performance, longer service life and lower maintenance costs. You also get prompt delivery because stocks are on hand to meet practically every need. Free engineering service is also available.

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THE ORIGINAL
FAST'S Couplings

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G. W. Wilcox knows what he's talking about. He should—he's been with Reed for 37 of the Company's 39 years of operation.

He started in 1921, just about the time the *first* slush-lubricated rock bit was being introduced to the drilling industry by Reed. Since then he's been on hand to play an important part as new Reed Bits have been developed to keep up with the requirements of ever-tougher, ever-deeper drilling. For example, he shared in the introduction by Reed of the application of *hard metal* to cutting surfaces, which greatly increased footage drilled per bit; and in the development by Reed of the first *roller bearing (anti-friction)* rock bit, which increased footage and lengthened bit life.

Son G. C. Wilcox has also been around for a while, having followed in his father's footsteps and joined Reed in 1943. He has seen at first hand the important Reed contributions of later years—such as the development of the *first* field-replaceable slush nozzle rock bit of Reed unitized design; and of course, the introduction of the most advanced rock bits in use today, Reed Y-Bits —the Regular type as well as the Jet type with exclusive Flush-Flo return ports, pictured at left.

Reed is proud to have loyal, capable employees like the father-and-son team of G. W. and G. C. Wilcox. They are worthy examples of the type of skilled, experienced craftsmen to be found on the Reed team.

Though product designs change to keep pace with changing needs, men like these are your assurance that Reed will always maintain *one* unchanging high standard—the Reed standard—of quality.

Reed Roller Bit Company

Houston 1, Texas

Inspection Leadman G. W. Wilcox, shown talking to his son, has been with Reed 37 years. His son, Electrician G. C. Wilcox, has been with the Company 15 years.

Specialty Fabrication for Processing Plants

Glitsch specializes in intricate tooling and fabricating of ferrous and non-ferrous materials . . . alloys and stainless steels. We design and fabricate kiln internals for cat-cracking units, reactor and regenerator beams and baffles, special piping, welding, steel components . . . in fact any equipment which must be expertly engineered for weight and strength ratios or special construction.

Whatever your requirements, you will find valuable experience and modern, complete fabricating facilities at Glitsch. And once we do a job for you, we know you will call us back because you will like the way our "Single Engineering Responsibility" complements your own production program. If you require any kind of specialty fabrication . . . for any process plant . . . call in Glitsch. Then you are assured of getting your job done right, and right on time. If you would like more information on Glitsch fabricating facilities, ask one of our representatives or write to us at P.O. Box 6227 in Dallas. There is no obligation, of course.

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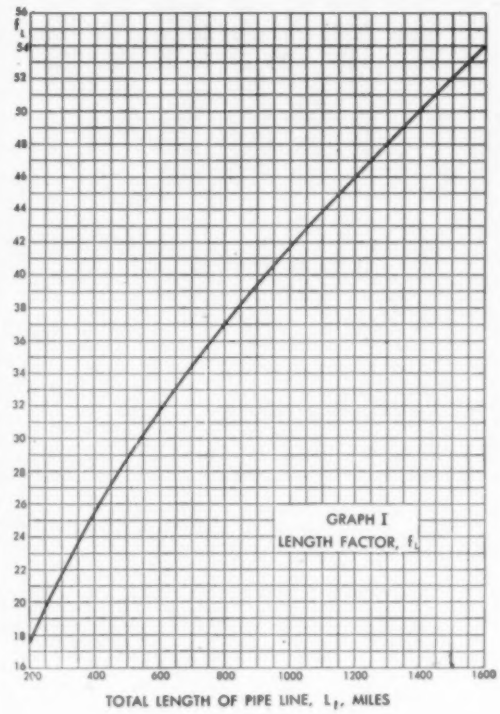
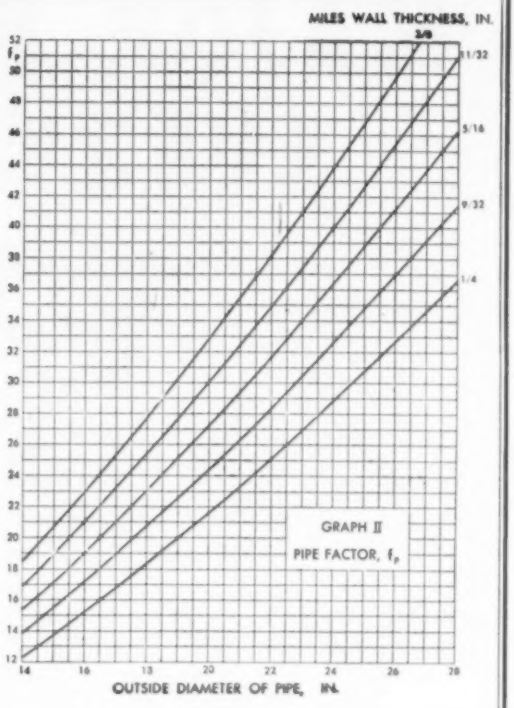
GAS PIPE LINE DESIGN FACTORS





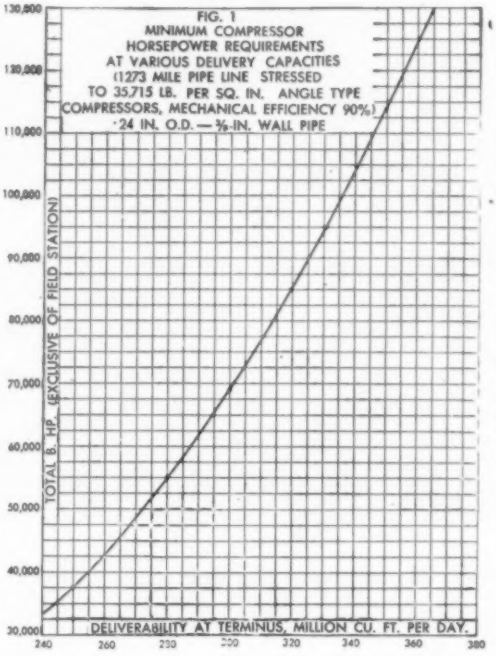


FIG. 1
MINIMUM COMPRESSOR HORSEPOWER REQUIREMENTS AT VARIOUS DELIVERY CAPACITIES (1273 MILE PIPE LINE STRESSED TO 35,715 LB. PER SQ. IN. ANGLE TYPE COMPRESSORS, MECHANICAL EFFICIENCY 90%) 24 IN. O.D. — 3/8-IN. WALL PIPE
TOTAL B. HP. (EXCLUSIVE OF FIELD STATION)
DELIVERABILITY AT TERMINUS, MILLION CU. FT. PER DAY.

These curves are taken from the article entitled "Solving Problems of Gas Pipe Line Design by Use of Significant Factors" by C. L. Brockschmidt and M. K. Hager that was published in *The Petroleum Engineer* in December, 1944, pages 142 to 164, inclusive.

Graph I (upper left) plots values of the length factor (F_L) vs. the total length of pipe line in miles (L_t).

Graph II (upper right) plots values of the pipe factor (f_p) vs. the O.D. and wall thickness of pipe.

Fig. 1 (lower left) is a plot of the optimum solutions of examples 1 and 2 as explained on Sheet 4 of this series. The conditions assumed for these examples are as shown at the top of Fig. 1. The optimum solution points used for constructing this curve are as follows:

Point No.	*No. of Stations*	*Deliverability, Cu. ft. per day*	*Total B. H.P., (Exclusive of Field Stations)*
1	5	250,000,000	37,500
2	9	300,000,000	69,000
3	13	350,000,000	113,800
4	5	280,000,000	55,000
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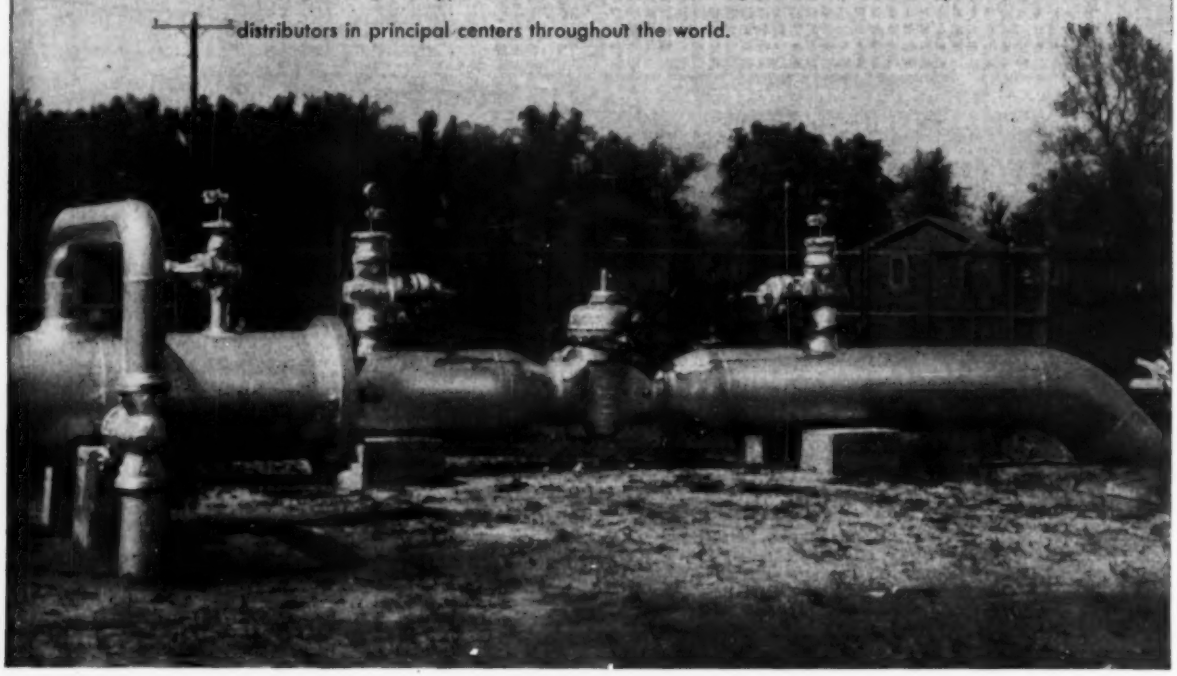

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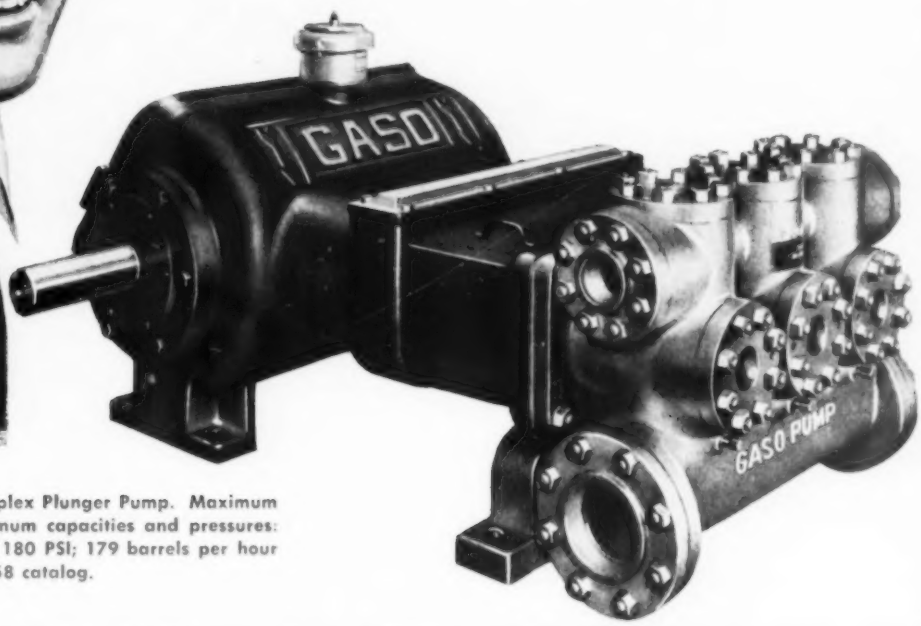

Fig. 3466 Horizontal Triplex Plunger Pump. Maximum speed, 250 RPM. Maximum capacities and pressures: 91 barrels per hour at 1180 PSI; 179 barrels per hour at 600 PSI. Write for 1958 catalog.

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1 in 4 Wildcats Successful
Export Volume Up 21%
800 Miles Crude Lines Built
2000 Miles Gas Lines Added
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H. G. Cochrane

Natural gas stole '57 show. Trans-Canada completed its 34-in. western leg to Winnipeg. Here pipe is ready to be pulled into Assiniboine River as part of dual crossing.

CANADA HAS GOOD YEAR

THE CANADIAN PETROLEUM industry has become so accustomed to 25 percent and, more recently, 30 percent increases in annual production of crude oil over the past decade, that increase of a mere 7 percent in 1957 over the previous year came as a shock. First signs of a leveling off began to appear during the second quarter. By the fourth quarter output fell behind that of the last quarter of the previous year by 2½ million barrels.

For the full year, however, a new record was again posted at 183 million barrels, up 7 percent compared with the 170 million barrels produced in 1956. Estimated gross value of production at $433 million compared with $408.5 million in 1956. That was a creditable showing in the face of only a 4½ percent gain in Gross National Product, and the sharp declines in rail traffic and in base metals, steel, lumber, and motor vehicle production, to mention a few.

Slower marketing pace noticeably affected development drilling during the latter part of the year. Production capacity is some three years ahead of indicated market growth and continues to increase at the rate of around 100 wells per month. Possibility that 1958 may show a further drop in domestic consumption and exports raised the question at year-end proration of development drilling.

Though development wells drilled during the year were down about 10 percent, a record number of wildcats drilled totaling 12 percent more than in 1956, the success ratio holding close to one-in-four ratio of the previous year. Footage of holes declined to about 15 percent below 1956. Active rigs at year-end were 20 percent fewer than a year previously.

Geophysical activity continued at a consistent pace. No major new oil pools were discovered in 1957 comparable to the finds in Pembina or Sturgeon Lake; however, important discoveries were made in the Innisfail area, the Virginia Hills, Swan Hills and Edith Lake areas and in the Kaybob-Iosegun area southeast of Sturgeon Lake, all in Alberta.

Saskatchewan, B.C. Output Up

British Columbia production exceeded 300,000 bbl for the first time, double its previous total output. On the other hand Manitoba, with production of some 6 million barrels, failed to duplicate the 37 percent gain in output recorded there in 1956. Only a gain of some 6 percent was shown for 1957.

Repeating the spectacular 66 percent gain in production experienced in Saskatchewan in 1956, producers recorded another 68 percent gain in output over the previous year. Much of this gain was at the expense of Alberta producers. With her many light gravity fields in the southeast corner of the province some 800 miles nearer Ontario and mid-U.S. markets, Saskatchewan producers have captured an increasing proportion of these markets with a 1957 output close to 36½ million barrels.

Export Pattern Changes

The export market for Canadian crude, which accounted in 1956 for a third of production, was substantially bettered during the past year. Healthy increase in export volume of some 21 percent over 1956 was encouraging, but was marked by a disappointing decrease in exports to the Pacific Coast and a sharp increase in exports to northern states. Collapse during the second half of the year in the export demand for westbound oil was due to softening of tanker rates, to a long refinery strike at Vancouver, and to general U.S. opposition to imports.

A realistic appraisal of all the divergent factors makes a forecast of exports for 1958 extremely hazardous. The down-trend in tanker rates, the extent to which natural gas may replace oil for heating, the possible imposition of fairly rigid import quotas across

For frozen muskeg and heavy snow conditions in northwestern Alberta, Shell equipped its seismic parties with tracked vehicles. Chassis and tracks are made by Bombardier of Quebec, while the bodies are designed and built to Shell specification in Alberta.

the border, and new supplies to the California market from New Mexico started in January, are all factors to be weighed. But the general feeling appears to be that a leveling off or moderate uptrend in exports of Canadian crude is to be expected during the coming year.

Canada Needs to Protect Oil

Of the three major American producing nations, Venezuela, the U. S. and Canada, only Canada has sofar failed to protect its domestic oil industry.

The U. S. last August applied "voluntary" oil import controls. But unless importers comply, control may be imposed by legislation. The plan may be extended to refined products. United States has substantially increased production in recent months, and is aiming at a further increase in 1958 with a target of raising U. S. production to more than 70 percent of the nation's producibility. By contrast, Western Canada ended 1957 producing at 45 percent of potential.

The tanker surplus was increased by imposition of U. S. controls, and is likely to continue through most of 1958. Tanker operators have been carrying oil at cut prices with no profit in preference to laying up their vessels. These tankers have substantially increased the flow of Venezuelan and Mid-East oil into Montreal.

Venezuela oil has been dislodging Alberta crude from northern California, and even from the Puget Sound market connected by pipeline from Alberta.

Further aggravating the Western Canadian industry's oil problems last fall was the import, up to the time the St. Lawrence froze over, of surplus U. S. refined products into Montreal at cut rates. These supplies came by distress tankers from the Gulf Coast, from U.S. Great Lakes refineries, and even up the Pacific Coast to Vancouver and thence by rail to Manitoba. With opening of navigation in the spring the movement may be resumed.

Duhamel Field, Alberta, where Mobil Oil of Canada, Ltd., is conducting exploratory and drilling operations. Alberta production was down for 1957 but Saskatchewan, British Columbia and Manitoba made gains. Overall Canadian output was up 7 percent.

Final protest to the United States on the West Coast import control program through diplomatic channels is planned, even though the cut on the West Coast would amount to some 4400 barrels daily or less. What Canada fears is that restrictions now would interfere with planning for expansion at home. Officials point out importing companies in the U. S. can still bring in Canadian oil, since the program does not specify the sources on which they must draw.

But in dwelling upon the worries over restriction of crude oil imports to United States, export of natural gas, and Canadian taxation policies, producers seem to be overlooking an important economic trend. It is that Canada is practically the only nation with any serious expectation of increasing oil production at all in 1958.

The increase promises to be close to the increase for the full year of 1957, and should include a moderate gain in domestic sales. Moreover, it was believed to be market conditions rather than import quotas that were limiting the movement of Canadian crude to the United States during the fall of 1957 and early weeks of 1958.

Eastern Market the Solution?

Alberta producers should set their sights on the Quebec market area now served with foreign crude from the big 250,000 to 300,000 bbl per day Montreal refineries, according to many of the independent companies. Here is concentrated about a third of Canada's refinery capacity. Most of the major integrated companies are strongly opposing the move.

Though capture of the Montreal market for western oil would raise western Canada's output by around 25 percent there would have to be a 10-cent cut in current wellhead prices all across Canada and other adjustments. Besides this, a second West-East oil pipeline could be financed only if and when the half dozen big Montreal refining companies sign long term throughput agreements to buy western oil exclusively.

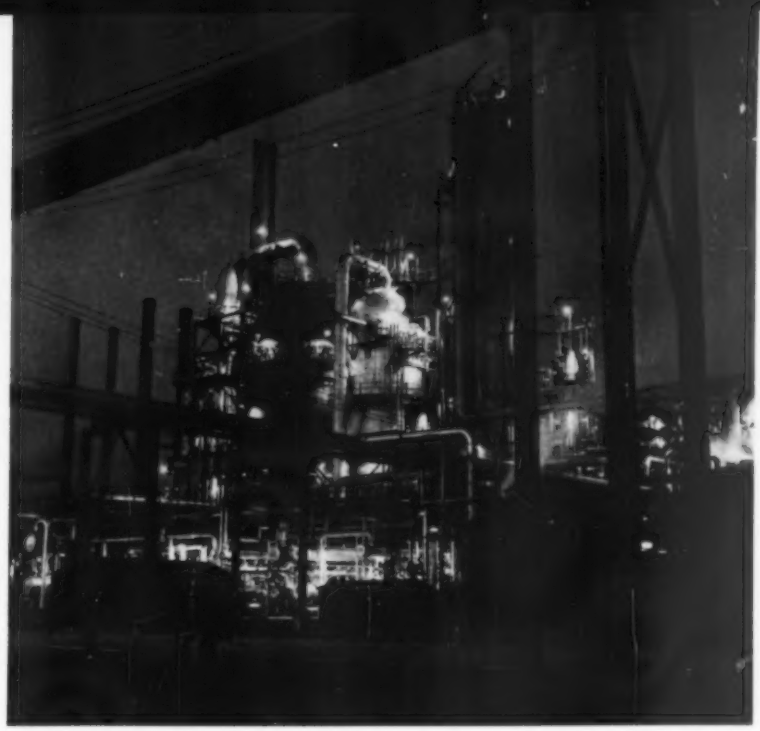
The independents argue pipeline charges could be readily re-adjusted upward for intermediate delivery points such as Toronto and Sarnia to permit a lower rate to Montreal. They also advocate a customs tariff on foreign oil at Montreal. But integrated companies foresee an assurance of price cuts by the present suppliers of ocean-borne crude. They also look for a bigger potential market in the United States within five to seven years. They believe it better for western producers to wait for this certain market rather than to cut wellhead prices and gain the Montreal market.

Refinery Capacity Up Some

Canadian refinery capacity moved up to 774,550 bbl per day in 1957, an increase of some 67,000 bbl per day over capacity at the end of 1956. Cracking capacity at some 336,000 bbl per day was reduced by 6600 bbl per day during the same period. Present crude refining capacity in barrels per day is divided as follows: Maritime provinces, 45,000; Quebec, 260,800; Ontario, 207,500; Prairie provinces, 192,000; British Columbia, 68,000, and N.W.T. 1300.

Cities Service and Shell are each adding 20,000 bbl per day capacity at Bronté near Toronto over the next two years. The shifting over of a presently operating Sarnia refinery to western crude will boost further the West's share of the Canadian market.

Construction will begin this spring on rebuilding and expansion of Imperial's Calgary refinery for completion in 1959, adding 6700 bbl per day to capacity. Shell's Shellburn refinery at Vancouver will expand for production of a wide variety of solvents, while North Star Oil has just completed arrangements for addition of catalytic reforming at St. Boniface, Manitoba.



Largest refinery in Canada is Imperial Oil's Sarnia, Ontario, refinery with 78,000 bbl a day capacity. Imperial will rebuild and expand its Calgary refinery in 1958. Western Canadian crude is now being brought to Sarnia, which will boost market.

800 Miles Crude Lines Added

Although the mileage of crude oil pipelines laid during the year was small compared with gas pipelines, more than 800 miles were laid, including 156 miles of new 20-in. line for Interprovincial Pipeline in Ontario from Sarnia to Port Credit outside of Toronto.

The balance was looping programs designed to provide in advance for expected increases in throughput in strategic regions. Trans Mountain's main pipeline was looped for 100 miles with 30-in. Westspur laid a 75-mile 16-in. loop in Saskatchewan, the Pembina Pipeline main was looped for 36 miles and InterProvincial looped 33 miles with 24-in. in Saskatchewan.

Westcoast Transmission is considering building a 650-mile "big-inch" crude pipeline from Peace River fields to Vancouver, paralleling the company's natural gas pipeline. The project may be two years away due to softness in the current market for crude on the Pacific Coast. Pacific Petroleums is also interested as a result of its development in the Boundary Creek, Fort St. John, and Buick Creek fields, which the line would tap. A similar line is planned to Bella-Coola by Act Oils Ltd., owned by Canadian Southern Petroleums and others.

Natural Gas Stole '57 Show

If Western Canadian oil producers were disappointed with their markets in 1957, natural gas producers, gas pipeline builders, and gas distributing utilities had good reason for enthusiasm. For them 1957 was a year of solid accomplishment. More than 2000 miles of main line and gathering system construction and at least 2500 miles of distribution systems in towns and cities including customer services were laid during the year.

With completion of the Westcoast Transmissions system in October, Peace River gas deliveries commenced to customers through the completed distribution systems in mainland British Columbia communities served by Inland Natural Gas Company. Canadian gas replaced imported gas in the Vancouver area and reversed the northward flow by feeding Canadian gas into the Pacific Northwest pipeline, south of the international boundary.

To the east, Trans-Canada completed its 34-in. western leg as far as Winnipeg by early September, and gas deliveries to Regina, Brandon, Portage la Prairie and Winnipeg commenced in the same month.

The long open fall weather permitted the Northern Ontario Pipeline Crown Corporation finally to reach Fort William-Port Arthur with its 310-mile 30-in. pipeline by the first week in December. By year end Alberta gas was available through 910 miles of line from Alberta gas fields to Lakehead cities.

Still further east, Trans-Canada's 20-in. section between Toronto and Montreal was completed to the Island of Montreal, as well as branches to serve Lindsay and the Ottawa-Hull area, awaiting a temporary supply of borrowed gas from the Dawn Township storage fields of Union Ges Company.

In southwestern Ontario Union Gas was close to completion of its 142-mile main pipeline from Dawn Township to Hamilton and to connect up with the Toronto-Montreal leg of the Trans-Canada pipeline.

Duplicate Pipelines Considered

Thus with natural gas available to most of the important centers across Canada, with exception of those between Lakehead and Toronto, and distribution systems in various stages of completion, a serious re-appraisal of Canada's export position is called for. The indicated rapid market build-up in eastern Canada and on the West Coast has exceeded earlier expectations. A maximum throughput rate, including export, of some 650 million cubic feet daily within four or five years is considered not only possible but practically certain.

This means both Westcoast and Trans-Canada must have vast looping programs underway by that time to provide added capacity for the next round of expansion. This in turn calls for more development of gas fields, the proving up of further gas reserves, and federal and provincial approval for the movement of further gas to these markets.

Several of the large gas distributing companies have forecast that within a year they will be in the market for

1963 contract volume increases ranging from 40 percent upward. Besides this are the potential fuel and raw material needs for large industrial, metallurgical and petrochemical application.

Gas Popular in Canadian Cities

If gas distribution companies' experience in Toronto and Vancouver is typical, there will be rapid acceptance of natural gas as a Canadian fuel in towns and cities all across Canada. Calgary and Edmonton in Alberta, of course, have gas at their doorstep, and have used it for many years in spite of competition from abundant and cheap coal from nearby mines.

Gas consumers of Toronto commenced building up its market in that city several years ago with a temporary supply of natural gas from Gulf States, pending arrival of Alberta gas late this year. Vancouver got a temporary supply from "The Four Corners" via Pacific Northwest pipeline about a year ago pending arrival of Peace River gas via Westcoast Transmission in September last year.

Reserves Build Up Rapidly

Western Canada's gas reserves are placed today at anywhere from 25 to 28 trillion cubic feet, of which 18.3 trillion are in Alberta. Alberta's 30-year requirements are estimated at 7½ trillion feet and exports approved to other provinces and the U. S. are 5.75 trillion feet leaving a present surplus of 5 trillion feet. It is estimated reserves are increasing at the rate of two to three trillion feet yearly, most of it incidental to the search for oil.

Recent major discoveries in Alberta's southwestern foothills and at East Calgary and Crossfield have added tremendously to reserves. The big Pembina oil field will also be a large gas producer once facilities are completed to make use of flare gas.

Search for natural gas to supply the various pipeline systems, completed and proposed, has spread to most of the areas tributary to them within the provinces of British Columbia and Alberta. Almost every active company has had a part, large or small, in exploration and development. Pacific Petroleums has played the major role in the Peace River and Fort St. John fields that are supplying Westcoast Transmission. Prominent among the groups that will supply Trans-Canada stand Canadian Delhi, British American Oil, Shell Oil and Provo Gas.

Active in exploration and development of gas fields for supplying the second West Coast project from Savanna Creek are Phillips Petroleum and Canadian Husky. Gas fields tributary to the proposed Canada Southern project include reserves of Canadian Western Natural Gas. A 500-mile gathering line is envisaged from the Fort St. John area through Pembina and Sundre, with possibly the south half of British American's Pincher Creek field. The East Calgary field, discovered by Jefferson Lake Sulphur and Merrill Petroleums would also be tied in, as well as recent Texaco foothill discovery at Castle River and the Shell Waterton find northwest of Pincher Creek field.

Huge machines conquer the Canadian terrain for oil operations. Here one of six traxcavators is clearing way for Westcoast Transmission pipeline. Gas line was completed in October.

Export Permits

Trans-Canada has an export permit from the Alberta government for 4.35 trillion cubic feet, subject to a daily limitation of 650 million cubic feet. It now appears these peak requirements will be met as early as 1961-62. Westcoast Transmission with government approval for a throughput of 660 million cubic feet per day, 83 percent of which is exported, applied early in 1957 for permits to increase its exports by 170 million feet daily from Savanna Creek field in southwestern Alberta.

Alberta and Southern Gas seek permission to export 450 million cubic feet per day to the California market through a 1300-mile pipeline through the Crow's Nest Pass costing $330 million. Competition among Westcoast and Canada Southern is stiffening wellhead prices and forcing Trans-Canada back into the gas buying role in Alberta.

Study Export of Energy

The first policy declaration on natural gas export policy by Canada's new Prime Minister Diefenbaker, was announced to Parliament November 1. The Royal Commission, chaired by Henry Borden, is to study the whole range of energy sources and uses. He stated Canada's policy on export of energy in any form would not be established until the Commission makes a formal report. Apparently no decision can be looked for until 1959. This was a shock to pipeline and gas company officials, and natural gas producers were deeply disappointed at the implied long deferment of further export permits.

Dr. John Davis, in a report he prepared for the Gordon Commission on Canada's Economic Prospects, released last December, stirred up considerable controversy regarding the export of natural gas. In it Davis points out that countries or states or provinces that produce energy and put it to work effectively at home, rather than those that produce the most energy, are the ones that reap the greatest economic benefits.

"Canada will benefit from development of its energy sources. But it will benefit more if a growing proportion of that energy can be put to work at home," the report states. "But this does not mean refusing to export energy we cannot use." Davis has assumed the wellhead price for gas will double in the next 25 years. He draws the conclusion that export of gas is not necessarily beneficial, that perhaps it would be better to keep the wells capped until there is a bigger market for it at home.

Editorially, "Oil-in-Canada" points out that "the basic fallacy in this reasoning is the assumption that there is any advantage in holding on to an expendible commodity in the hopes of an ultimate price rise. This was done very effectively by John MacFarland with wheat in the early 'thirties,' — so effectively that Canada has not yet recovered some of the lost markets." ★

What a Petroleum Economist Does

Here is a rare and interesting article about the functions of an economist in an oil company — a role that has developed into an indispensable part of a successful organization. You can learn:

Problems of coordination committees and how an economic unit can help them.

Specific do's and don'ts for organizing a satisfactory economic advisory unit.

Advice on how to select and maintain an adequate staff . . . department proves excellent training for executives.

Breakdown on what management wants and how to build up information and analyze it.

Serge B. Jurenev

THE PETROLEUM INDUSTRY prides itself, and rightly so, on being one of the largest, most progressive and best managed industries in this country, and for that matter, in the Free World. To staff its expanding and increasingly complex operations, it has created a demand for men with new types of skills.

In response to the petroleum industry's call, technical schools have brought into being during the past few decades the petroleum geologist and geophysicist, the reservoir engineer, and a variety of experts in the fields of petroleum technology and petrochemicals.

But the industry itself, rather than any school, had to produce its own breed of economist — the petroleum economist. To do so it had to draw initially on academic circles, financial and investment institutions, and on certain government agencies, such as the Bureau of Mines, for men with general economic training and background. The industry has also brought up some of its own talent from the ranks in the operating departments. The creation of the new breed of economist has been a slow and painstaking process. Because it was started recently, it is far from being completed.

Those of us who pride ourselves on being petroleum economists have one thing in common: We are creatures of the management of our respective companies. Among the several degrees which most of us hold, there is no such thing as a master's or doctor's degree from any established school in the science of petroleum economics. We learned our lessons in this science on the firing line of active operations of an oil company. Naturally, as is the case with every firing line, there have been some casualties.

Before going into reasons for such failures as have occurred, two more immediate questions need answering:

1. What circumstances prompted management decisions to create a novel job of a petroleum economist?

2. What does it take to be a petroleum economist and to be able to meet management's requirements?

To answer the first question, let us look at the makeup of an integrated oil company. As the saying goes, it is a

Paper presented to a session on Petroleum Statistics at annual meeting of American Petroleum Institute, Chicago, Illinois, November 13, 1957, under title of "Functions of an Economist in an Oil Company."

The Author

S. B. Jurenev *joined Continental in New York in 1942 and two years later became secretary and assistant treasurer. He was promoted to secretary and treasurer in 1948. He organized the coordinating and planning department in 1948 and the following year transferred to the company's executive offices in Houston, Texas. He returned to New York in 1953 as assistant to the chairman of the board of directors. He was promoted to assistant to the president and chief economist in 1956. Born in Russia, Mr. Jurenev studied mechanical engineering at the Imperial Institute of Technology in Russia and received his bachelor's degree from the University of Prague in Czechoslovakia. He also holds a master's degree in business administration from Dartmouth College. Before joining Continental, he was associated for 16 years with J. P. Morgan and Company.*

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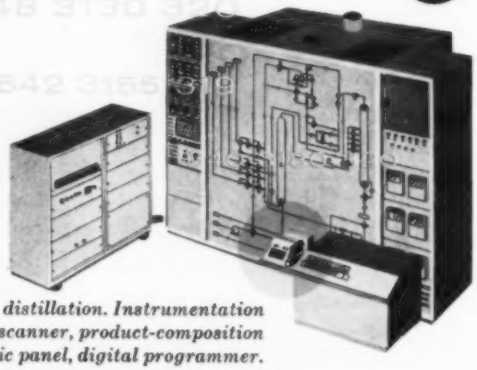

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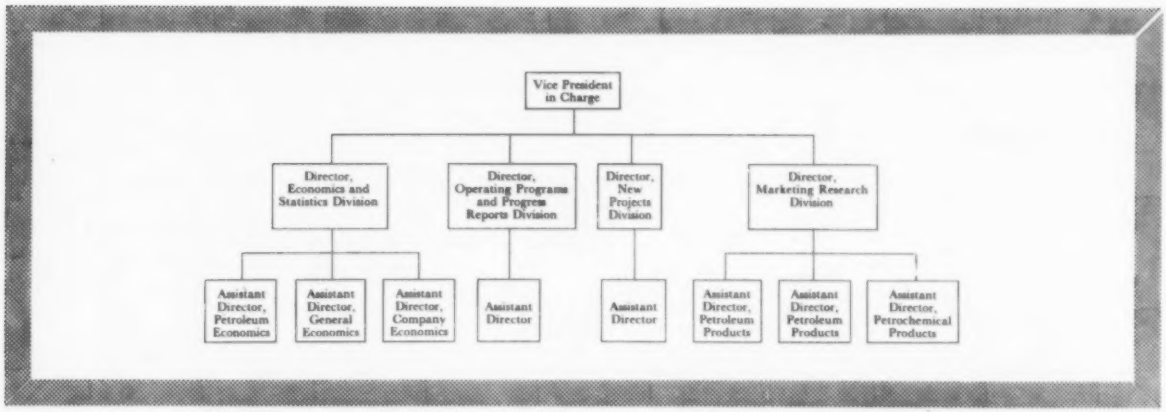
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Organizational Chart of Continental Oil Company's Coordinating and Planning Department.

combination of four legitimate widely divergent businesses and of a crap game, all rolled into one piece. The crap game, of course, is the exploratory end of our operations. The four legitimate lines of business comprise crude oil production, crude oil processing and petrochemicals, transportation, and marketing.

The more complex and wider spread geographically these functions become, the greater is the need for overall coordination. But proper coordination of operations of existing facilities is only one of the many major tasks which the management of an oil company faces.

Equally important is the programming of future operations and direction of the flow of capital into new facilities. Consequently, the oil industry management is continually faced with two basic problems:

1. Most efficient and balanced operation of present facilities.

2. Proper channeling of additional funds into new facilities which are selected on the basis of their relative profitability.

A logical solution of the coordination and programming problems was found in the creation of interdepartmental committees. Committees of this nature now exist under various names in almost every good-sized integrated oil company.

These coordination mechanisms are confronted with a set of problems which, in varying degrees, are common to all integrated oil companies. Generally these problems can be subdivided into:

1. Problems resulting from changing trends in general economic conditions or changing trends in the petroleum industry. These changes in trends vitally affect the pattern of every oil company's operations.

2. Problems originating within the company and peculiar to it. These problems may be caused by lack of coordination or by inadequacy of information supplied to top management.

3. Problems connected with expansion, construction, or acquisition projects. Some of these projects may be a part of long range programs or of regular budgets. Others may be of a special nature and may have been originated by departmental or regional managers, by subsidiary companies, or by top management itself.

These problems should not be approached from a departmental or regional viewpoint in a coordination committee, because:

1. Outside economic influences and competitive conditions in the industry play a decisive part in making decisions, and in the timing of decisions. Departmental managers or regional managers are confronted with day-to-day operating problems and have no time to build up an adequate background of general economic or industry information.

2. Activities of an integrated oil company in the production, manufacturing, transportation, and marketing fields are so closely interrelated and interdependent, that a proper balance is needed at all times. Such a balance can be struck only if the coordinating mechanisms, and top management itself, are continually supplied with complete and objective appraisals of the operations of individual segments of the business.

3. Budgetary allocations for capital expenditures should not be, but sometimes are, the result of a tug of war among departmental or regional managers. A departmental or regional presentation of a project is likely to be partisan and confined to its own field, notwithstanding all the good intention to the contrary. Management, which sits in judgment on such a tug of war, needs a clear cut and unbiased appraisal of basic facts.

If the reasoning presented so far is accepted, it becomes apparent that the effectiveness of the various coordinating mechanisms in an oil company can be considerably enhanced through use of analytical and economic thinking.

Obviously, one man could not possibly encompass all segments of an integrated oil company's activities. Therefore, whenever reference is made in this paper to a petroleum economist, what is meant is not only the top man himself, but also his staff, which comprises an economic unit. Size of the unit naturally would vary from company to company. Objectives of such a unit, irrespective of its size, would be briefly:

1. It should give due weight to general business and industry trends insofar as they affect an individual project or decision.

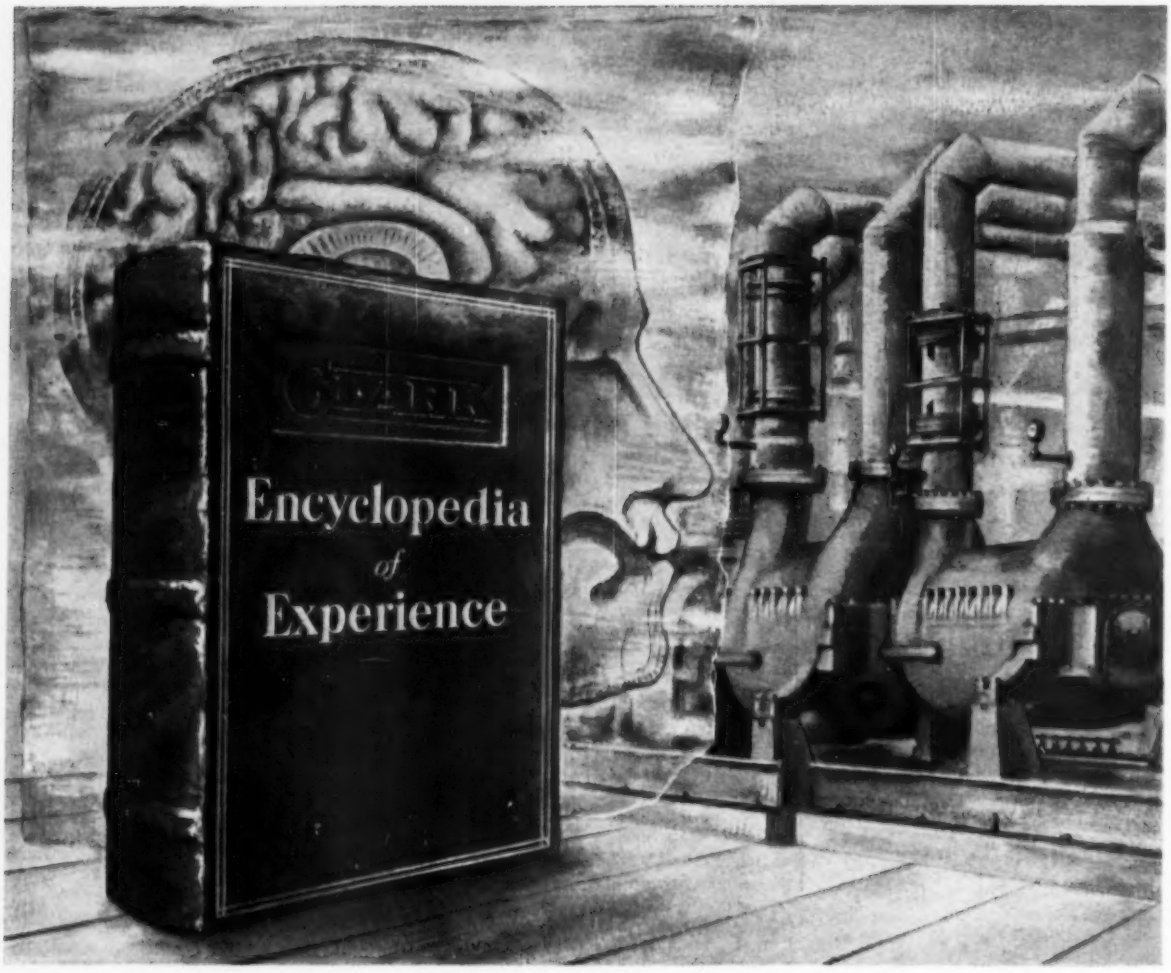
2. It should approach all problems from an overall company viewpoint and not from a departmental or regional viewpoint.

3. It should be objective and truly analytical in its reports. The unit should be able to weigh properly all factors, bringing out the cardinal points and eliminating those not essential.

4. It should report promptly, before decisions are made. Reports should consist of: (a) Brief summary of findings and recommendations; and (b) supporting data to which management can refer if the summary is not sufficiently exhaustive and convincing.

Initiative for the creation of an economic advisory unit obviously must come from management.

There are many instances when top management itself is not wholly satisfied with the effectiveness of existing coordination mechanisms and seeks to



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supplement them by an economic unit.

In other instances, a central economic unit is the result of a fusion of bits of economic work done by small staffs formerly scattered among various operating departments.

Whatever the origins of an economic unit are, its objectives and problems are essentially the same. To achieve its objectives it must have a strong support from top management, particularly in its first faltering steps. This support generally covers these points:

1. Manager of the unit must be placed in a proper slot on the organization chart and be given sufficient prestige and authority. He should rank equally with other members of the coordination committee and should report to one of the senior officers of the company.

2. He must be given ample opportunities to build up his contacts and sources of information within the company. Outside contacts in the industry, financial, and economic circles should be encouraged.

3. Organization of the department and its functions should be thoroughly discussed and understood both by the man in charge and by management.

4. Within limits set by management, the manager should have authority to select and hire his staff members, subject to approval of a senior officer.

If these prerequisites are met, it is up to the manager from here on to show his mettle and make himself of real service to the company. Unless a favorable climate is created from the start, the newly created department may easily become a casualty on the firing line.

Here are a few don'ts which, if not observed, would render an able petroleum economist wholly ineffective:

1. Don't form an elaborate economic unit and make it responsible to an assistant controller or assistant treasurer.

2. Don't place an economic unit under an operating department head. Such a unit is bound to become a mere adjunct to that particular department.

3. Don't staff the department with deadwood on the assumption that a petroleum economist can transform older clerical people into sharp analysts.

4. Don't give the manager of the economic department any administrative or executive authority over any departments of the company other than his own.

It would be interesting to know to what extent the do's and don'ts outlined above have been tested by various oil companies. To my knowledge no complete history of the development of the economic work in the oil industry has been written as yet, no doubt because of the relative newness of the subject. Since my knowledge on the overall picture is quite sketchy, I believe that it would be more proper for me to discuss our own experience.

It so happens that just about a decade ago I was assigned the task to organize a coordinating and planning department for Continental Oil Company. Development of this department may well parallel the experience of other oil companies which have established economics departments by now. It may be also of interest to those who are in the process of building one up.

When L. F. McCollum became chief executive officer of Continental in 1947, he instituted changes in an evolutionary, rather than revolutionary, manner. No coordinating and programming mechanisms existed in the company when Mr. McCollum took over. Operations of the company were gradually changed from a highly centralized to a decentralized basis, with great delegation of authority and responsibility. Organization of the coordinating and planning department was only one of the many facets of the new way of life. I am glad to say that the department has played at least some part in the change from management by intuition to management based on thoroughgoing appraisal of facts, figures, and on sound judgment.

The coordinating and planning department was organized on the initiative of the chief executive himself in order to reinforce and support the newly formed inter-departmental coordination and programming committees. From the start, McCollum has given vigorous support to the coordination and economic work, with the result that over a 10-year period the department has grown into an indispensable tool for top management.

Present setup of the department, which consists of about 50 people, is illustrated by the chart. Professor John McLean, who came to us from Harvard Business School, took over management of the department in February 1956. I should like to mention that in addition to the various degrees Professor McLean holds, he is a *petroleum* economist.

Like most of us, he learned his lessons on the firing line of active operations, starting with Continental back in 1948, first as a part time, and later as a full time, consultant. Further proof of McLean's being a *petroleum* economist can be found in his little pamphlet called "The Growth of Integrated Oil Companies" (728 pages, price $12, can be purchased on an installment basis).

The department as it is today has reached its maturity and is getting a college education. But let me turn back to the days when it was a newly born baby and when I had to guide its first faltering step and nurse it to adolescence.

The four major problems with which I was confronted 10 years ago, and which I believe still exist to some extent in every economic department were:

(1) Establishing proper relationships with the heads of the operating departments. (2) Selecting and *maintaining* **an adequate staff. (3) Carrying on a continuing process of training people. (4) Building up adequate records and sources of information on general economics on the petroleum industry and on company operations.**

1. When coordination mechanisms of a company and its economic unit grow together, the economist has to question pet projects of operating departments, bring out unpalatable facts and express doubts about some deep seated, but sometimes unverified, premises underlying departmental policies.

Such kind of activity, at least at first, does not place the economist in the front rank of anybody's popularity poll. I have learned, however, that so long as the economist displays a sincere desire to help solve problems rather than to score personal advantage, he can dispel initial doubts which operating departments may have about a brand new economics group.

I have also learned to be humble in cases where I did not have enough facts or technical knowledge, but on the other hand, to go against what seemed to be the prevailing opinion, if the facts and figures at my command warranted it. Once it becomes clear that the economist attempts to be a helpful adviser and not a sniping nuisance, confidence and mutual respect develop. One should never fail to make every effort to maintain this kind of atmosphere once it is established.

2. Personnel is an ever continuing problem. If the department is to serve a useful purpose, it should be staffed from the start by well trained people who are analytically and not clerically minded. The ideal situation would be, of course, to have nothing but accomplished petroleum economists. Ten years ago this kind of staff was sheer Utopia — there just were not that many petroleum economists on the loose. But even if enough of them were available, the costs of providing such a staff would be prohibitive. Also, consideration had to be given to employees of the company who may have had analytical ability and the ambition to develop it.

A proper balance was reached in our

case by using: (a) Several well trained analysts who could train and guide the junior members: (b) company men from operating departments who proved valuable in analyzing the company's performance because of their familiarity with departmental operations, and (c) college graduates preferably with BS or MBA degrees.

It was the writer's recommendation to management at the time the coordinating and planning department was started to have a preponderance of ambitious youngsters who could be trained to become the brains of the organization, rather than a large number of higher paid mediocrities from the ranks.

3. Another problem is *maintaining* an adequate staff. Keeping the right kind of people in an economic department is as hard, if not harder, than getting them in the first place. The usual pattern of our personnel problems runs something like this: First you carefully pick out of the ranks, or hire on the outside, a fellow who has analytical ability and the ambition to develop it. Then you spend endless hours training him. Training means continually working with your men and giving each of them periodic pats on the back for things done right, and alternatively vigorous kicks in the pants for things done wrong.

Every good manager faces similar problems in selecting his staff and training his people, but once the training is finished, he usually keeps his men. Well, the manager of an economic department usually does not. And here is where the main difference lies between the personnel problems of the manager of an operating department on one hand and of the manager of an economic department on the other — the latter trains his men in the face of a foregone conclusion that he is bound to lose them. And what is worse, the better the men are, the quicker they will go somewhere else.

This is only natural. The bright, well trained young fellow in the economic department becomes widely known in the company. He is fair game for any operating department head or regional manager who is in need of an assistant or of a good staff man. And, invariably the time comes when the manager of the economic department is faced with a dilemma — should he put his foot down and keep a good man, or should he let him go to the greener pastures in the operating end of the business?

The answer is obvious: Let your man go, even if he happens to be the best one you have. If you don't you will ultimately lose him anyway, and many more to boot. By its very nature, the field of activity in an economic department is limited. And so is the size of the department and opportunities for advancement within the department.

By contrast, in an operating department or in regional administration, opportunities open up at frequent intervals. Trying to keep your men forever in the economic department and denying them an opportunity to better their position in the company will completely ruin the esprit de corps of the department.

None of the original members of the staff of our coordinating and planning department are there today. They are scattered in company operations from the Gulf Coast to Canada. Of the senior men, one is now an assistant general regional manager, another is the manager of the natural gas department, and the third is an assistant treasurer.

I derive some nostalgic pleasure in saying that two of my men were at different times lost to a large bank and a stock exchange firm. At long last we reversed the flow and made financial institutions bid high prices for men trained by petroleum economists. So you see, our problem is not that of keeping our original staff. This cannot be done. We have to maintain an adequate staff of constantly changing composition.

4. Problem of building up adequate records is an obvious one. Technicalities of establishing an uninterrupted flow of information are too involved to be discussed here. So, let me turn now to the crucial test of the effectiveness of any economics department — its ability to supply management the kind of information it wants and expects to get.

Clearly, management is not looking for table after table of statistics or page after page of abstruse mathematical formulae. Neither is management interested in long winded theoretical discussions couched in unfamiliar economic lingo. Management is not seeking a mere reporting of day-to-day events nor mere speculations as to future prospects.

What management wants are appraisals of various projects, interpretations of fact, analyses of changing economic and operating problems, and some reasonable forecasts.

Therefore, it expects the manager of the economic unit to be a man with analytical training and organizing ability. He should have enough imagination not only to face current problems but also foresee problems to come and have material on hand to meet them in the best possible manner.

The manager and his senior assistants should find enough time to cut out, without any mercy, non-essentials from all studies before they are submitted for consideration by management, but always be sure that all the essentials are there.

Above all, every study submitted should contain definite conclusions and recommendations. This gets the economist into that uncomfortable exposure characteristic of a spot far out on the end of a limb. On such occasions, I have always taken comfort from the maxim that was dear to the heart of the former president of Harvard, James Bryant Conant, and which I should like to pass on to you as a closing paragraph of this paper: "Observe the turtle — he only makes progress when his neck is out." ★ ★ ★

China Boasts Oil Expansion

The People's Daily of Peking, China, reported on January 9 that work will be completed this year on the country's first oil pipeline, 150 kilometers long (93 miles), from the Karamai oil field to the Tushantzu refinery in northern Sinkiang, Northwest China. The oil refinery will be expanded to handle more crude oil.

A number of new oil wells will be sunk in the Karamai oil field, which has a known oil reservoir area of over 100 sq kilometers (62 sq miles), about seven times bigger than the known oil reservoir area in the Yumen oil field, the present biggest producing center in China.

The Ministry of Petroleum Industry has planned to drill test wells with a combined depth of 350,000 meters (114,828 ft). Total footage of 130,000 meters will be drilled this year.

Crude oil production capacity increased by 127,000 tons (952,500 bbl) and oil refining capacity by 410,000 tons (3,075,000 bbl) as a result of the new oil wells drilled and refineries expanded in 1957.

Prospectors last year located workable oil fields in the Tsaidam Basin, discovered new oil zones in the Kuuchuan Basin similar to that of the Yumen oil field in the same area, and confirmed the practical workability of China's biggest natural gas area in the southern part of the Szechwan Basin.

Construction will be continued on a modern oil refinery in Lanchow, Northwest China. Shale oil refineries in Fushua, China's biggest oil shale producing center, in Northeast China, will be expanded this year.

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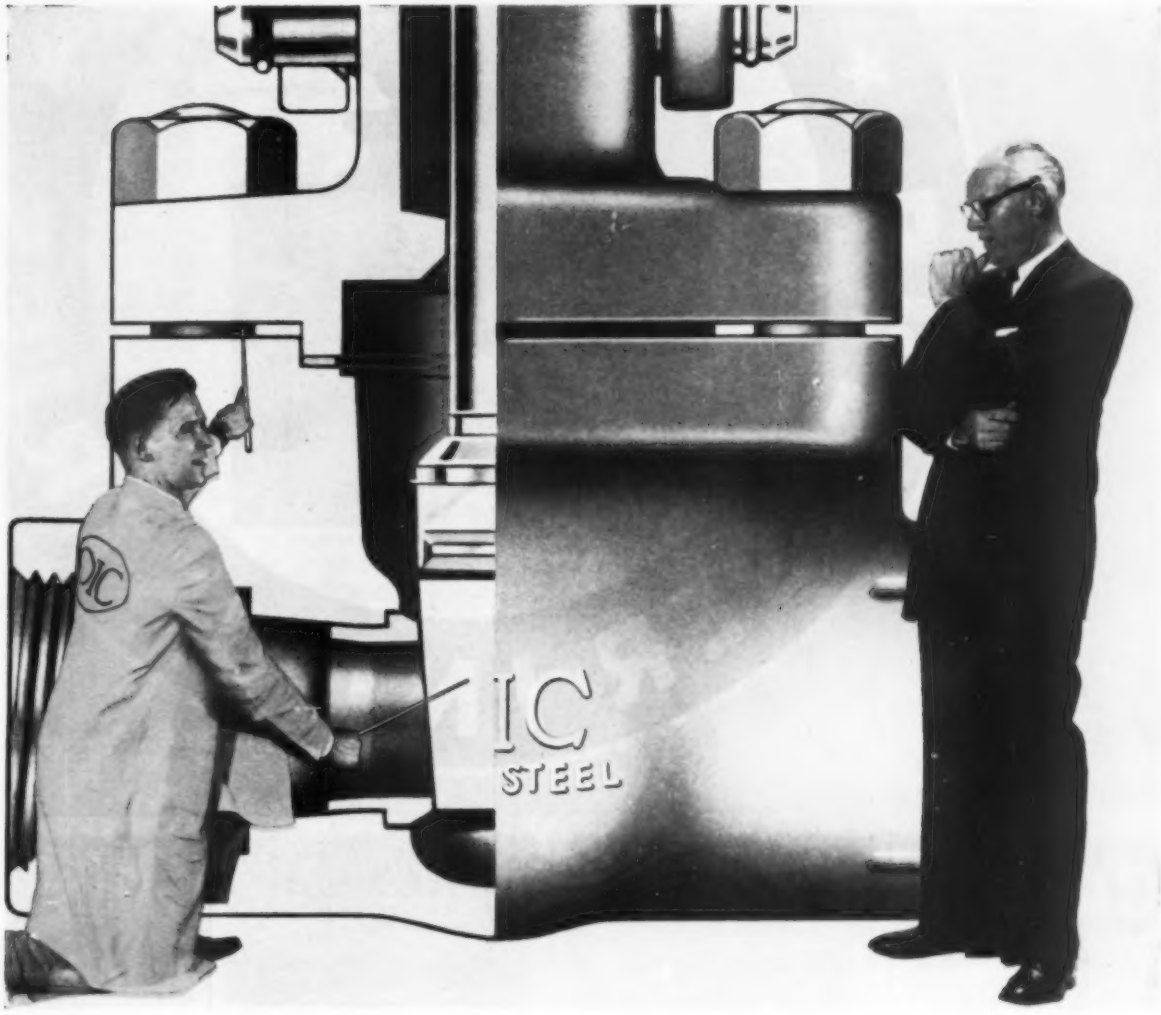

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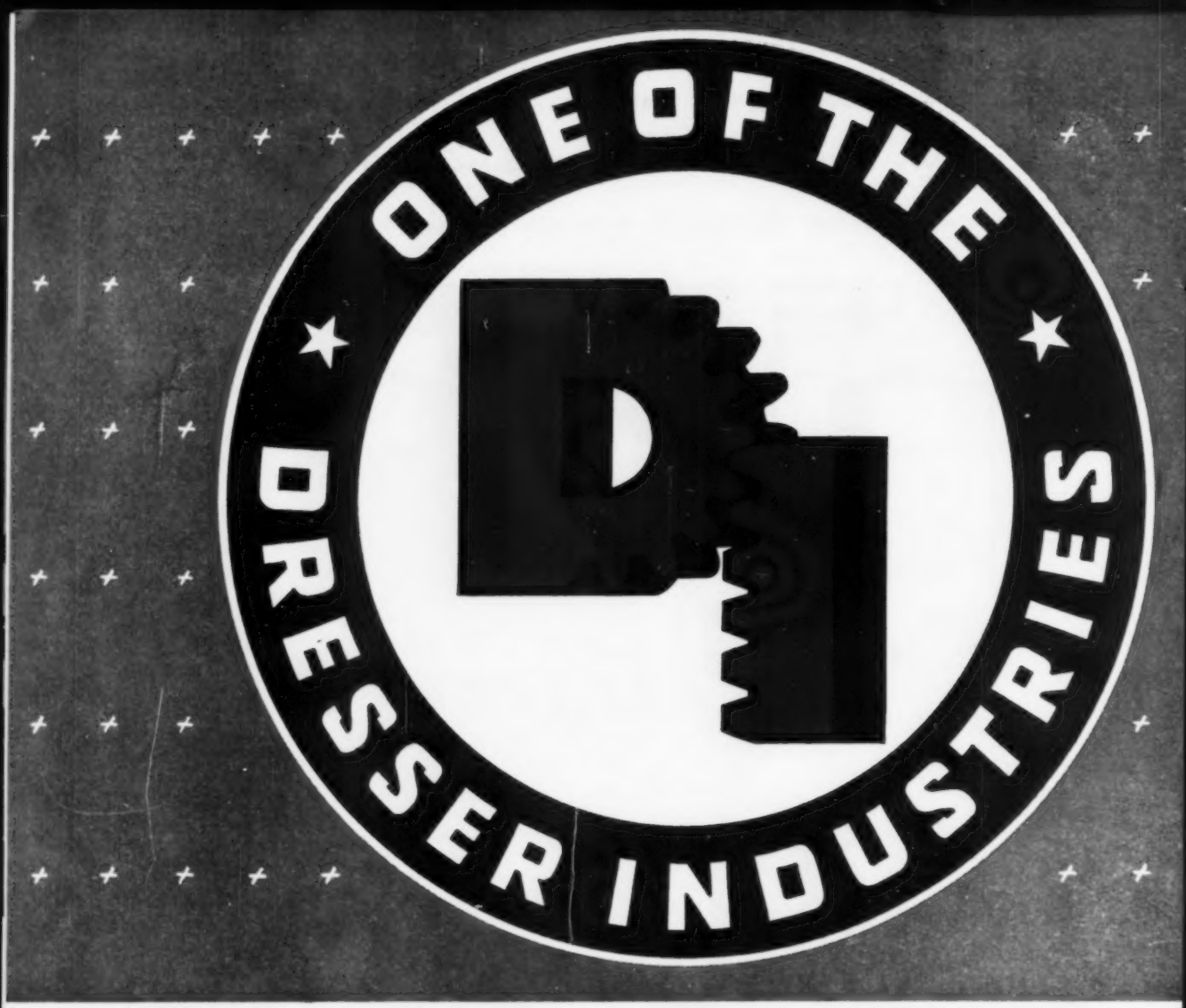

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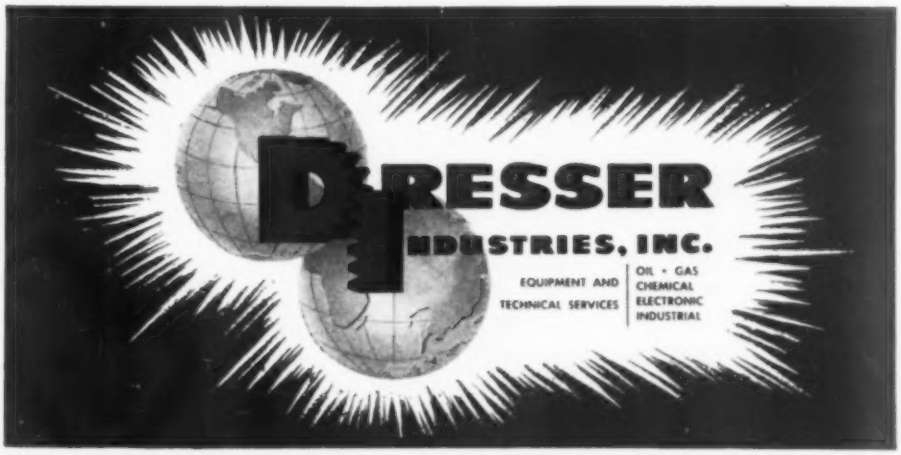

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Human Factors in Good Supervision

Ernest W. Fair

DAY-TO-DAY problems of supervision in a gas utility company are never easy to solve. The ways and means used by supervisors to simplify and expedite the work require continuing study.

Not the least of the factors that call for more investigation is an understanding of the human factors involved in getting the most out of our men. Modern machinery needs only a friendly tap of a wrench or a liberal portion of lubricant dessert to supply cooperation. Not so with the men who use this equipment.

From actual job experience, here are some of the short cuts to the practical supervision of personnel. It may also be noted that they apply the psychological approach that the same individual's wife uses to get him to do those extra chores around the house.

Job Interest

First is a thorough realization that no man can work efficiently who does not have an **interest in his job.** A dutiful husband may empty the garbage for the little woman, but he does it reluctantly. He will display the same lack of enthusiasm for his work on the job unless supplied with a vital interest in that work.

Such interest is inborn in some individuals. But as every foreman knows, men such as these are scarce as television sets at a theater owner's convention. It is one of the primary functions of his job to supply that interest to the men who work for him.

No job can be too drab or routine without some element of interest. In many cases, all the foreman has to do is to discover or create that feature and then point it out to the individual employee. In the routine of daily work we often overlook a score of such interesting factors. Whenever a deliberate effort is made, these interests will become readily apparent.

Ultimate results of a man's work can often provide such interest. Or, the routine skills he uses can be glamorized and made more important to him. Emphasis on increased perfection (presented without wifely nagging) can arouse an interest in seeking perfection on any job. Foremen should never overlook an opportunity to give such ideas to their men.

Attitude Is Important

Second human factor we can profitably keep in mind, is to remember that **ability can be developed if an attitude is present.** Without the proper attitude, no amount of sweat on a foreman's brow can develop ability.

Attitudes are made in great measure by interest in an individual's work, as well as by the foreman's approach. Development of ability depends in great measure on the foreman's ability to arouse the proper attitude of each man toward his work.

When the individual has a negative attitude toward his work, and shows sufficient evidence of skill or ability to make the effort worthwhile, it will pay any foreman to exert a positive effort toward the elimination of such a negative attitude. Until this has been accomplished, 90 percent of his teaching efforts will be wasted.

I give up on Mike — he's a stubborn mule that just won't learn — he simply has the wrong attitude, a foreman was heard to say. Mike may have been a stubborn cuss. But, the practical approach was not a continued pounding by the foreman on job instruction, but careful planning to remove Mike's mental or emotional obstruction. Once such a roadblock has been set aside the task of teaching and instruction, which is a vital part of every foreman's job, becomes as easy as feeding ice cream to a growing boy. Foremen who use this system accomplish their purpose by carefully searching for what lies behind the negative approach in Mike and his fellow workers. Once discovered, these negative ideas are easily removed and positive ones supplanted. Then, ability can be developed to its maximum peak.

Another factor the wise foreman always keeps in mind is that **abilities can**

remain hidden if no one tries to bring them out. No girl really knows how to kiss until she meets an expert; it seldom comes natural despite what the songs declare. The ability to do a good job at any [illegible] will likewise remain hidden until the foreman makes a deliberate effort to show the employee the proper response.

Once upon a time there was no income tax—and once upon a time foremanship called for a hard and fast taskmastership over the given skills of every employee. Now, we have plenty of income tax. If we had as wide an application of an intelligent approach by foremen toward developing skills and abilities of their employees, supervisory tasks would be less exacting.

Man really started taking over the face of this earth when in the dim prehistoric days he began using his fingers and thumbs for purposes other than clouting his fellow creatures. The chances are there was one particular individual who was the leader in developing these abilities. He was the foreman of prehistoric times.

Overcoming Inertia

Next on the list of short cuts is a thorough realization that the **average man has a built-in resistance to change.** Unless we keep this in mind, it will take three or four times longer to develop a worker's major skills than it would if we approached the task with this principle. Old working habits sometimes need to be changed. This cannot be accomplished overnight. The foreman who realizes that each man has a resistance to change built into his physical and mental make-up, is the one who always secures the most with the least effort from his men.

It is also important to keep in mind that in order to unlearn an emotional habit, one must supplant it with another. This is always a slow process; try to hurry it and results will never be forthcoming. We are all creatures of emotion, and the emotions necessary to properly approach our jobs do not come naturally.

Most foremen with experience are aware of this factor in handling men, but surveys show that far too many supervisors have the idea that changes can be made quickly. It's a slow process . . . *almost as slow as getting a new idea through the Russian political mind.*

When there are workers who are obviously not satisfied with their jobs, yet show sufficient skills and abilities to warrant their retention on the payroll, the first step should be to try to discover what are their undesirable emotional conflicts and then try to relieve them. After this has been done, conflict on the job is reduced, and the foreman can spend more time reading magazines such as this.

Slant Appeals

Another factor in good foremanship is that **different appeals are needed to obtain different results. One wife uses soft words to get her husband to do an unpleasant task, while another finds liberal application of tongue-lashing brings more results.** Likewise a different approach is needed toward the individual on the job.

Formulas are nice. If we could discover one method of handling a given problem it would simplify our work. But, when it comes to personnel, there simply are no hard and fast formulas. Each man requires a different appeal. The foreman who finds and uses the right approach generally is the one whose department has the best work record.

Human factors in good employee supervision are as important as any other phase of the job. When made a routine part of daily procedures, the tasks of supervision and getting the work done are always simplified. ★ ★

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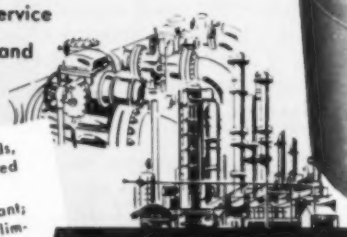

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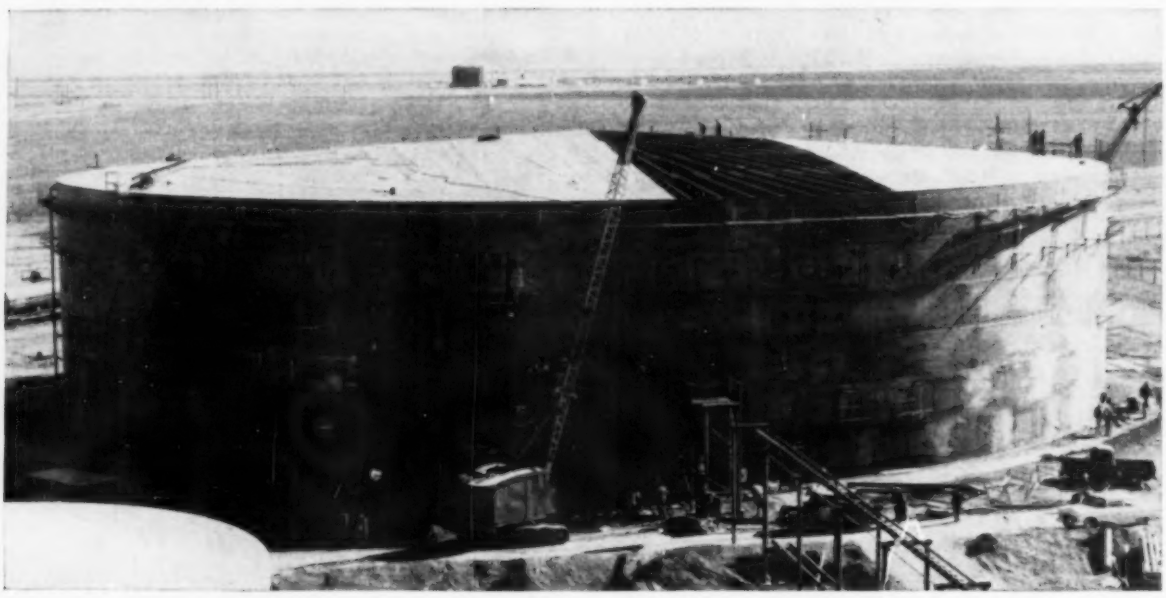

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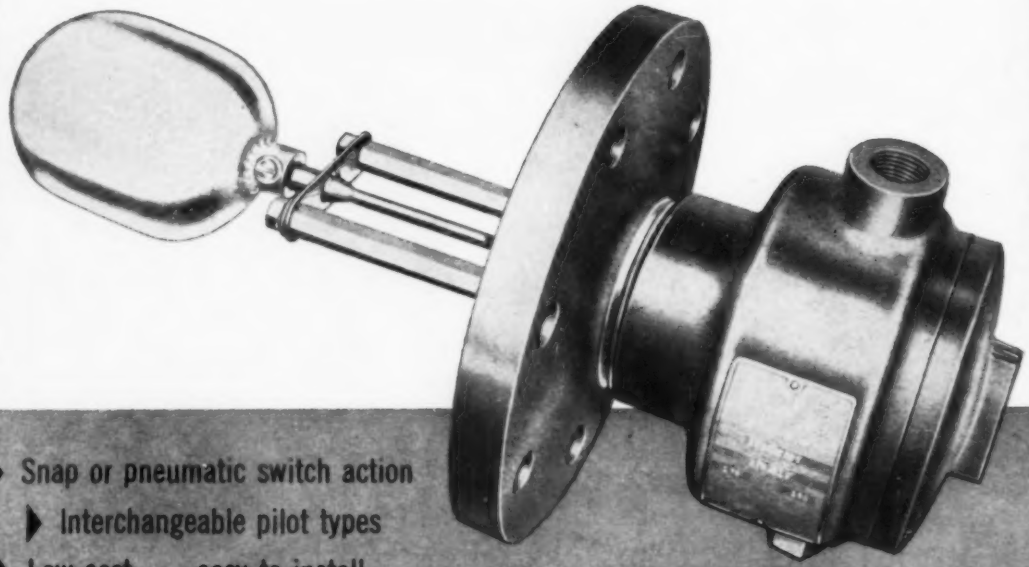

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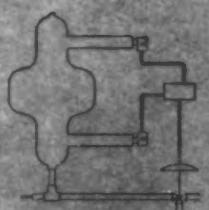

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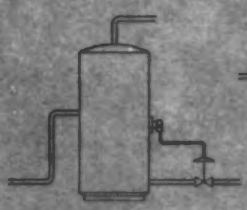

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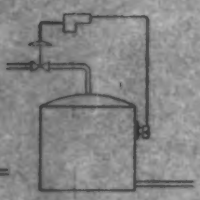

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Type 2806—Pneumatic relay with snapping range of ½" to 1¼", with 20 psi air supply.

Type 2807—Pneumatic relay for throttling service. Available with horizontal or vertical floats for wide range of proportional band requirements.

The float actuated 2800 series is a low cost, snap acting liquid level control available with either electric (explosion-proof) or pneumatic switch action. Pilot is interchangeable on float housing assembly. Features the stab-in type of tank mounting for easier installation.
Write for Bulletin F2800 for complete information.

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FISHER® Controls

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Management Personals

Marion J. Epley Jr., was named assistant to the chairman, The Texas Company. He has been general attorney for Texaco in New York since 1953.

Lewis L. Purkey, 47 years of service with Standard Oil Company of California, has retired. Purkey formed and has directed Standard's department on organization.

T. F. Bradshaw was elected a member of the board of The Atlantic Refining Company. He fills the unexpired term of **Philip G. Wharton,** who is retiring as a vice president and a director of the company. Bradshaw, general manager of finance and accounting for Atlantic, has been a vice president of the company since January of this year.

Mrs. Jaiyeola Aduke Moore, a Nigerian lawyer who served as legal advisor and later as secretary of Mobil Oil Nigeria (Socony Mobil), becomes first woman director of a Mobil company. She joins boards of both Mobil Oil Nigeria, a marketing company, and Mobil Exploration Nigeria.

John C. Duffy, treasurer of Murphy Oil Company of Oklahoma, Inc., was elected vice president. In 1951 he was head of the accounting department of Murphy of Oklahoma, later becoming an officer and director. **David M. Thornton,** formerly associated with Martin Logan Moyers Martin and Hull, was named head of the land and legal department of the company.

R. S. Hatch, general manager, materials supply and traffic, and **P. H. Arnot,** general manager, operations, were elected vice presidents of Arabian American Oil Company. Both will continue to make their headquarters in Dhahran.

Gerald B. Shea, chief of the Bureau of Mines' Region II division of petroleum technology and superintendent of the Bureau's Pacific petroleum experiment station at San Francisco, received the Department of Interior's highest honor, its Distinguished Service Award and Gold Medal. The award recognizes Shea's "outstanding contributions to petroleum technology, to the conservation of petroleum resources in the United States and other countries, and to the reduction of accidents in the petroleum industry."

C. Kenneth Eilerts, physical chemist and petroleum engineer of the petroleum experiment station of the Bureau of Mines, Bartlesville, Oklahoma, received the Distinguished Service Award and Gold Medal, also. This honor comes to Eilerts "in recognition of far-reaching vision and insight into the behavior of petroleum reservoirs, especially those of the condensate type, for leadership in putting new-gained scientific knowledge into practical effect, thereby conserving natural resources of petroleum, and for outstanding service in Government as a scientist of international reputation."

J. M. Linehan and **S. D. Breitweiser** were elected directors of D-X Sunray Oil Company, filling vacancies created by the resignations of **W. C. Whaley** and **R. H. Wills.** Linehan, formerly president of Mid-Continent Pipe Line Company, recently was elected a vice president of both Sunray Mid-Continent Oil Company and D-X Sunray, and will be manager of crude oil transportation and supply for the companies. Breitweiser joined the company in mid-1957 and is D-X vice president for marketing. **I. H. Hughes,** a vice president of Sunray Mid-Continent, was elected a vice president of D-X Sunray and will be manager of administrative functions for the two companies. In addition to Linehan and Breitweiser, other D-X Sunray directors are **R. W. McDowell,** president; **G. E. Wynn** and **T. E. Fitzgerald,** executive vice presidents, and **D. C. Wixson** and **R. Paul Henry,** vice presidents.

J. A. Reid, who was director of research for Phillips Petroleum Company, was named executive vice president and general manager of Astrodyne, Inc., newly formed company by Phillips Petroleum and North American Aviation, Inc. **T. E. Myers,** who was manager of plant engineering for North American's Rocketdyne division becomes vice president and assistant general manager.

Officers of the new corporation include: **J. L. Atwood,** president, who is president of North American; **R. W. Thomas,** who is Phillips vice president for research and development; **R. A. Lambeth,** treasurer, who is North American's vice president-finance, and its treasurer, and **Paul J. Parker,** secretary, is secretary and assistant treasurer of Phillips. Eight officials of the two founding companies were elected as directors of Astrodyne. From North American, they were: Atwood; Lambeth; **J. S. Smithson,** vice president-administrator; and **S. K. Hoffman,** vice president and general manager of North American's Rocketdyne division. Phillips officials elected as directors of the new company were: **Paul Endacott,** president; **Stanley Learned** chairman of the executive committee and assistant to the president; **W. W. Keeler,** executive vice president, and Thomas.

WHEELING

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⅛" to 12" — Seamless and Special Processed — Black or Galvanized

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1" to 4" — Seamless

EXTERNAL UPSET TUBING COUPLINGS A. P. I.
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Chicago, Ill. — Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo. — W. G. Cline & Co., 4500 Kalamath
Detroit, Mich. — R. W. Lang, Jr., 505 Park Avenue
Erie, Pa. — R. J. Maggi, Box 711
Falmouth, Mass. — Walter S. Bennett, 53 Minot St.
Grand Rapids, Mich. — R. W. Lang, Jr., 138 Burton SE
Houston, Tex. — Henry H. Paris Distributor, Inc., Box 932
Independence, Mo. — Craig A. Fross, 3701 Norwood
Los Angeles, Cal. — James A. Riordan Co., 1400 Santa Fe Ave.
Louisville, Ky. — Sid Schultze Co., 849 S. 6th St.
Milwaukee, Wisc. — W. G. Nelson Co., 3347 N. 97th St.
Narberth, Pa. — Worthington-Grothaus and Associates, 105 Forrest Ave.
New York, N.Y. — Max Rothenberg, 11-05 38th Ave., Long Island City
Newark, N. J. — Ira L. Rothenberg & Assocs., 398 Market St.
Omaha, Nebr. — Wm. Freiden, Central States Engineering & Sales Co., 5101 Blondo St.
Oswego, N. Y. — Northeastern Associates, Neil Chatterton, Sec'y. P. O. Box 284
Portland, Ore. — J. G. Beard Co., 1233 NW 12th Ave.
Richmond, Va. — P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo. — Walter C. Dollinger Co., 4869 Goodfellow Ave.
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• Industry • People • News — The Trade PARADE

Bucyrus-Erie Given Award

Bucyrus-Erie Company, excavator and drill manufacturer, was given a national award of merit January 25 by the American Association for State and Local History. The award was for *Designed for Digging: The First 75 Years of Bucyrus-Erie Company*, a 384-page, illustrated book on the company's history.

Builds Stores Aboard

Construction of two new store buildings outside the United States recently was completed by Mid-Continent Supply Company, president Ken W. Davis announced. The two new buildings are at Estevan, Saskatchewan, and Maracaibo, Venezuela. Both stores, which are topped by Mid-Continent's familiar derricks, carry complete stocks of oil field supplies and equipment.

Store manager at Estevan is B. J. Dickey and district manager is C. W. Crabtree. Mid-Continent's Canadian locations are under the supervision of division manager R. L. Harris.

The Maracaibo store is under the direction of Maracaibo manager, O. G. Garner. Venezuelan manager is J. W. Davis at Caracas.

Projects Outlined

Forty-eight employees of Rector Well Equipment Company representing management, engineering, production, and sales departments, gathered at the company's general offices in Fort Worth for the annual sales meeting in January.

L. L. Rector, president, announced the company is installing IBM equipment for high speed electronic accounting, billing, and inventory control. J. L. Pinkard, sales manager, said the company has installed new facilities at Odessa, Texas, for assembling, testing, and cleaning Christmas tree assemblies — both new and used. John L. Curry, manager of the cementing equipment division, presented three new products which the company is currently putting into production.

New Distributorships

Waukesha Sales & Service, Inc., Houston, is new distributor for Climax line of gas engines. Addition of the Climax line of gas engines ranging up to 600 hp will enable Waukesha to offer engines for services requiring power capacities intermediate between the ratings of many of its existing models.

Ideco, Inc., one of the Dresser Industries, Dallas, Texas, was appointed exclusive export representative for Kelco catheads and other products. Ideco will handle sales and service of Kelco spinning and breakout catheads, air-operated slips, and Fulgrip tubing tongs. No change will be made in Kelco representation within the United States and Canada.

Delta Tank Manufacturing, Baton Rouge, announced appointment of Mid-Continent Supply as exclusive distributor of Delta's oil field equipment. The sales agreement under which Mid-Continent assumes sales and service of Delta oil field equipment throughout the world with the exception of Mexico links two major members of the petroleum industry.

Warehouse Completed

Five thousand square feet of space for stocking complete lines of Christmas trees and wellhead parts, in addition to assembly, testing and renovation services are incorporated in the new warehouse recently put into operation by the Oil Center Tool Company three miles east of Lafayette. The new facility will service South Louisiana.

District manager is D. L. Tanner. Sales representatives working out of the South Louisiana headquarters are Gil Lastrapes and Charles Linscomb. Warehouseman is Bob Chachere.

Moves Into New Building

A nearly threefold increase in annual business in two years by the Machinery and Systems Division of Carrier Corporation was celebrated Friday (January 17) at a customer open house in the division's new district office building in Houston. More than 300 area leaders attended.

Acting as hosts with Gordon V. Bond, district manager, were Hermann C. Hoffmann, general sales manager, from executive headquarters, Syracuse, N.Y.; Oscar H. Mehl, southwestern regional manager, and Harry M. Shedd, senior industrial compression specialist, both of Dallas, and Richard A. Thompson, in charge of the industrial compressor department in Houston.

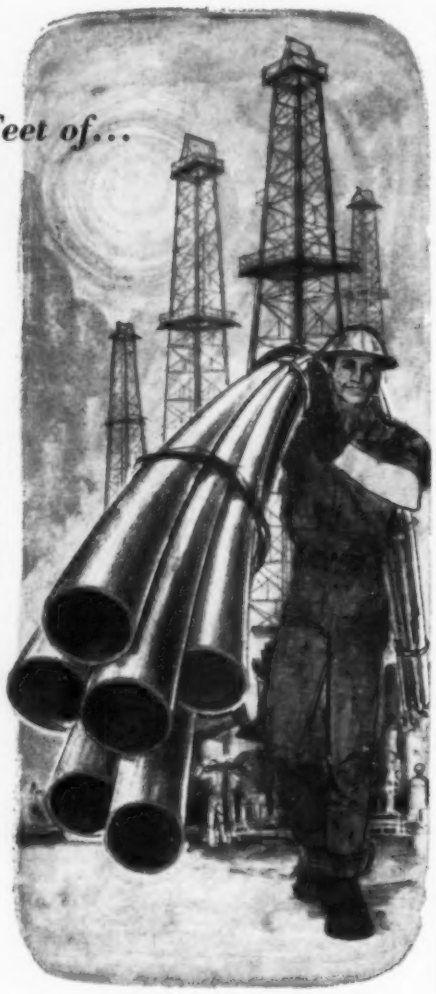
Over One Million Feet of...

KRALOY

HIGH-IMPACT

PVC PIPE

in oil-country use today



This proves that there is no substitute for Kraloy experience.

KRALOY is the most experienced manufacturer of PVC plastic pipe for the petroleum industry. The first polyvinyl chloride lead line installed in this country—at Great Bend, Kansas—was Kraloy Pipe. Kraloy High-Impact PVC today is preferred by production men for maintenance-free service in lead lines and disposal systems. Kraloy customers use Kraloy High-Impact PVC pipe for lead lines, gas lines, and salt water lines because Kraloy normally eliminates (1) sulphur corrosion due to sour crude, (2) paraffin buildup, (3) corrosion and scale, (4) trouble from soil electrolysis.

YOU Benefit From KRALOY'S Quality Control

To insure quality control, random samples of Kraloy Plastic Pipe are tested daily in Kraloy's own laboratory for burst pressure, impact resistance, and tensile strength under standard ASTM specifications.

Kraloy Pipe is Sold Only Through Qualified Supply Stores

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N. Y. 20, N. Y.

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DALLAS 30, TEXAS

The Mack Company, 2005 Hackney St.
HOUSTON 23, TEXAS

Ross Howell, 209 E. Scott St.
WICHITA FALLS, TEXAS

The Becker Sales Company, P. O. Box 2262
TULSA, OKLAHOMA

The Becker Sales Company, 716 S. 29th St.
OKLAHOMA CITY, OKLAHOMA

Robinson Oil Field Specialties, 616 Main St.
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6P-102

200 GPM +400 GPM 600 GPM

The PLUS value of Layne Gravel Wall Wells

400 GPM more water delivered by the use of a Layne Gravel Wall Well

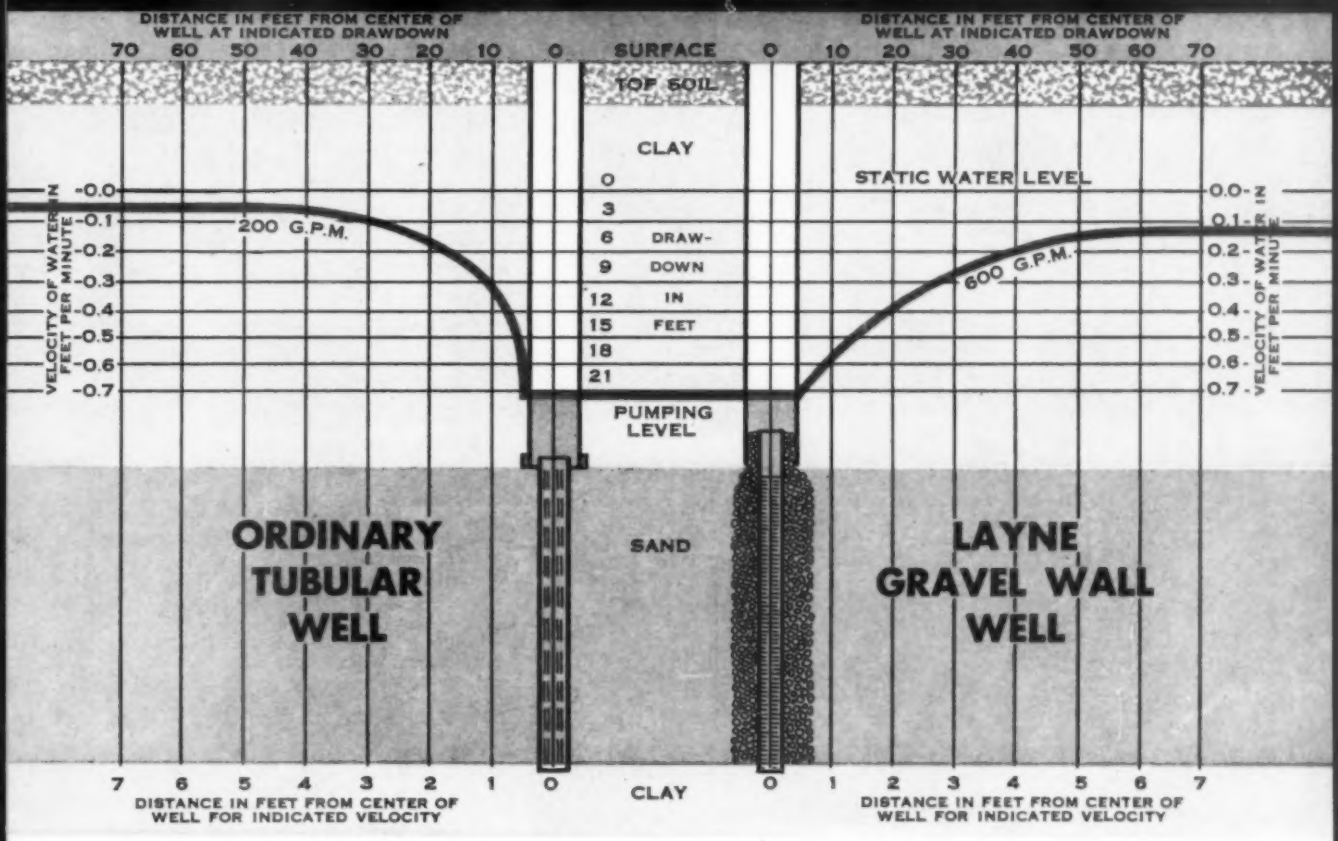
Adequate water and economy are important considerations in every step of petroleum processing. That's why men in the field rely on Layne.

Layne underreamed gravel wall wells equipped with Layne screens permit large screen openings which allow greater inlet velocities and reduce friction which in turn reduces wear on the shutter screen. Drawdown is moderate, pumping head low and operating costs proportionately lower.

Layne gravel wall wells are another example of Layne's experience and leadership in the field—gained around the world for over 75 years.

Our only concern—our only business is water.

PRODUCTION AND OPERATING CHARACTERISTICS OF TWO TYPES OF WELLS.



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Trade Parade

FOLLOWING ACQUISITION of Arnold O. Beckman, Inc., by Beckman Instruments, a broadening of Beckman's Process Instruments division product lines was announced by Mark K. Howlett, division manager. Former Arnold O. Beckman, Inc., instruments to be marketed by the division include oxygen and dissolved oxygen analyzers, gas density balances, and thermal conductivity and combustibles analyzers which are utilized in the chemical, petroleum, refining, power, metals and food industries.

SALE OF DU PONT'S American Glycerin section, an oil and gas well shooting service, to the newly formed American Glycerin Company, Inc., Bradford, Pennsylvania, has been made. Du Pont will continue to manufacture explosives and other devices for well-shooting, and the American Glycerin Company will offer shooting service to the petroleum industry.

LONE STAR PLASTICS, Fort Worth, Texas, has completed remodeling and expanding its plant, Melvin Hare, president, has announced.

New offices and departmentalizing of certain other activities will double capacity of this research engineering and custom manufacturing plastics firm.

GROUND WAS BROKEN recently on a 30-acre tract in Denver that is the site for Gardner-Denver Company's second plant in this area. Officiating at the ceremony were B. C. Essig, a member of the board of directors, and C. H. Rieman, vice president and manager of the Denver division.

RUST-OLEUM HAS COMPLETED $600,000 plant expansion program, according to Robert A. Fergusson, president. New additions include enlarged office space and a new company cafeteria at Evanston, Illinois. The manufacturing division has a three-story warehousing unit and a new ball mill equipment and automatic packaging system.

KIMRAY, INC., OKLAHOMA CITY, manufacturer of oil and gas equipment and controls, announces appointment of International Gas Lift as distributor for Kimray products in Peru and Ecuador. IGL, headed by John V. Herasimchuk, maintains offices and warehouse stock in Talara, Peru.

OPENING OF A NEW STATION in Lake Charles, Louisiana, is announced by John B. Merritt, executive vice president of BJ Service, Inc., a subsidiary of Borg-Warner Corporation. According to Merritt, the new station is one of the most modern and most complete in the country. It is fully equipped to handle the toughest, deepest cementing jobs in the Gulf Coast.

DOW CHEMICAL COMPANY announces opening a new sales office in Dallas Federal Building, 1505 Elm Street, Dallas, Texas. Donald P. Camp, former head of chemicals sales with the company's Houston office, has been appointed manager.

NEGOTIATIONS ARE in progress for a combination of Consolidated Electrodynamics Corporation, Pasadena, California, and Cenco Instruments Corporation, Chicago, Illinois. Though the exact legal form that combination of the companies will take has not been determined, tentative agreement has been reached that the ratio of exchange will be on the basis of three shares of Cenco stock for one share of Consolidated Electrodynamics stock.

DALLAS, TEXAS, DISTRICT sales office of A. M. Lockett & Co., Ltd., sales engineering representatives of Babcock & Wilcox's boiler division, was moved to 1701 Mercantile Dallas Building, 1807 Commerce Street.

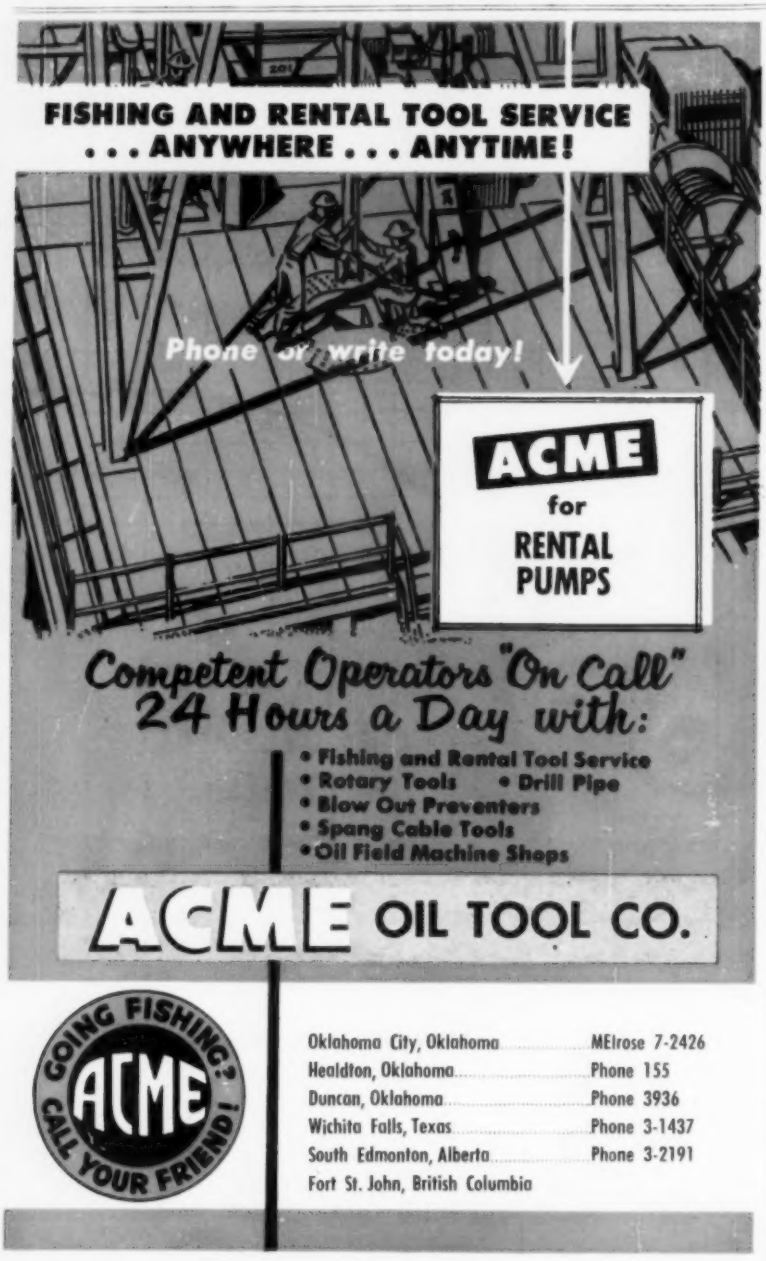
GATES FOUNDATION will offer a series of four-year scholarships to Colorado high school graduates for undergraduate study at any accredited college or university in the United States, Charles C. Gates, president of Gates Rubber Company, announced.

IDECO, INC., one of Dresser Industries, was appointed exclusive export sales representative for the Oil and Gas Equipment division of Graver Tank and Manufacturing Company Inc., it was jointly announced by George W. Walton, president of Ideco and J. E. Fogarty, vice president and general manager of Graver's Mid-Continent division.

Ideco, manufacturers of drilling equipment, has agents, affiliates (Dresser A. G. and Dresser International) and service representatives in active oil areas throughout the world. Manufacture of the Graver line of oilfield equipment is centered in its Sand Springs, Oklahoma plant. Products include lease storage tanks, oil and gas separators, heaters, treaters, cold separation units, glycol dehydrators, and allied oil production items.

Ideco has also been appointed to handle all sales and service except U. S. and Canada for Kelco products, according to an announcement by Ben F. Kelley, president of Ben F. Kelley Co., Inc., Tulsa, Oklahoma.

Continued on page E-31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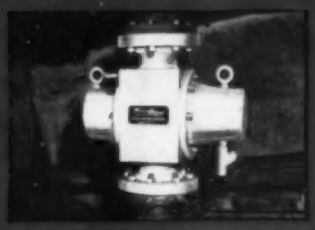
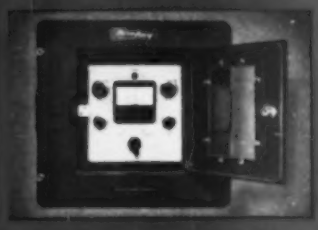
AccuRay® offers continuous flow density systems

Accurately measuring liquid density, specific gravity, percent solids or related quantity, the AccuRay Density System applies nuclear radiation measurement to process control. Without contacting the process material, measurement is made continuously, independent of flow rate, pressure or viscosity. The AccuRay System is stable and rugged—designed to withstand shock and vibration under the most adverse industrial conditions.

This precision system opens the way to greater profits through optimum control in deep well mudding, insuring a superior primary cementing job, detecting an interface during pipeline transfer, or tackling a difficult refinery density measurement.



AccuRay Measuring Head Is Easily Installed In Pipe System—Flange Connections.



The AccuRay Density Instrument visually indicates variations in fluid density—may be located remotely from measuring head.

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THE TAPE COATING THAT'S AS MODERN AS YOUR "UNDERGROUND HIGHWAYS"

Pipeliners discover this time-tested protective coating (polyethylene tape by Polyken) goes on faster... with less labor... and racks up real savings

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Strong, durable Polyken tape *(black spool)* is made of remarkably inert polyethylene . . . resistant to the corrosive effects of moisture, soil chemicals and electrolytic current.

Two examples of modern transportation—superhighway and pipeline—one aboveground, the other below.

But pipe goes places where roads are never seen. Through wooded wilderness . . . across frozen wastes . . . under broiling desert sands.

Polyken adhesive tape coating helps to make the going easier. It requires no primer, no hot dope preparation, no cooling or drying time. Wraps on cleanly, quickly . . . allows pipe to be buried immediately.

Crews are small (about half the size of hot dope crews). Labor costs are low . . . so are handling and equipment costs. And construction efficiency is amazingly high.

Polyken is the tape of experience with a long record of actual use in protective coating. For further information contact the Polyken Sales Division, 309 W. Jackson Blvd., Chicago 6, Illinois. Dept. PE-3.

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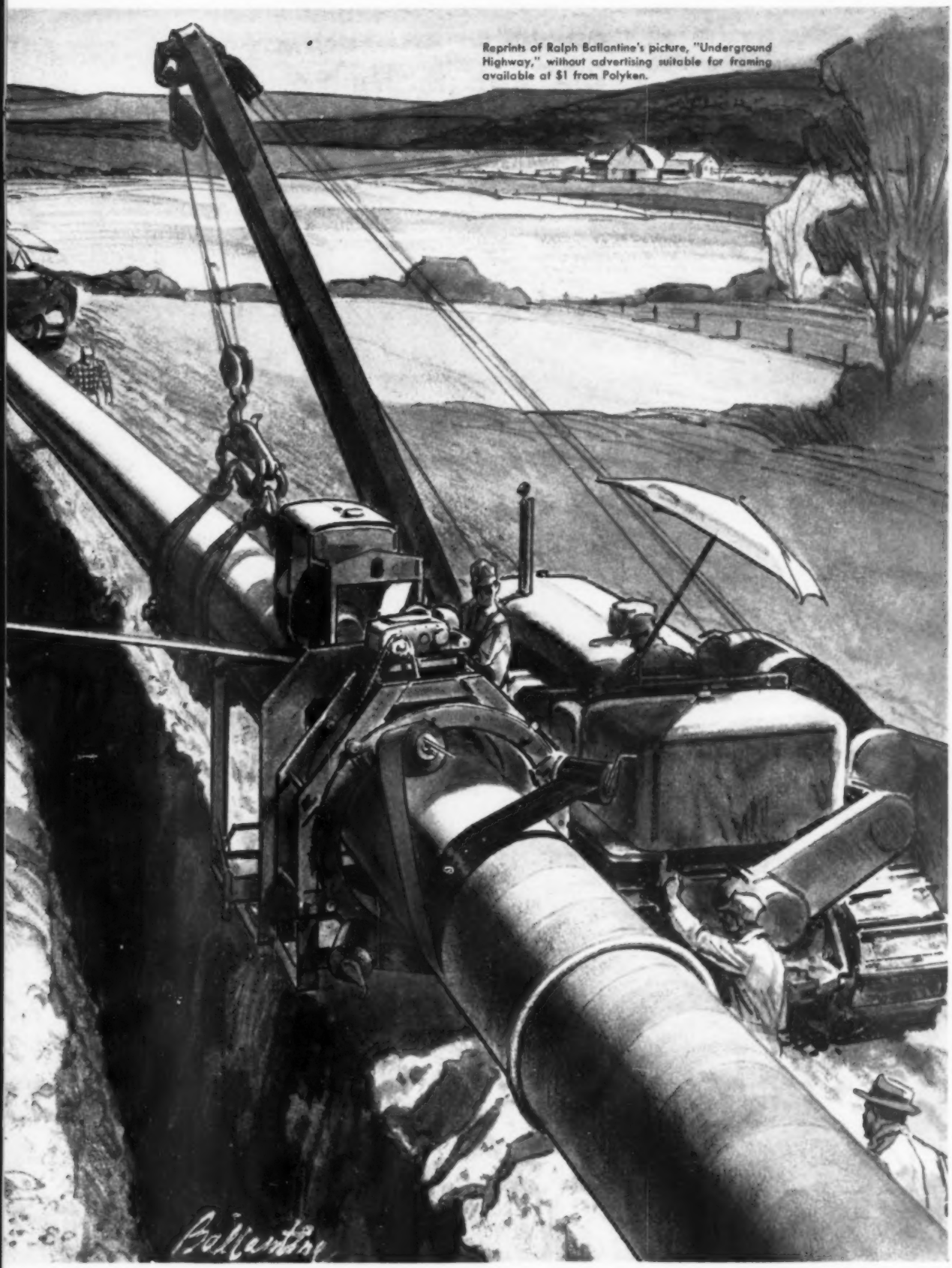
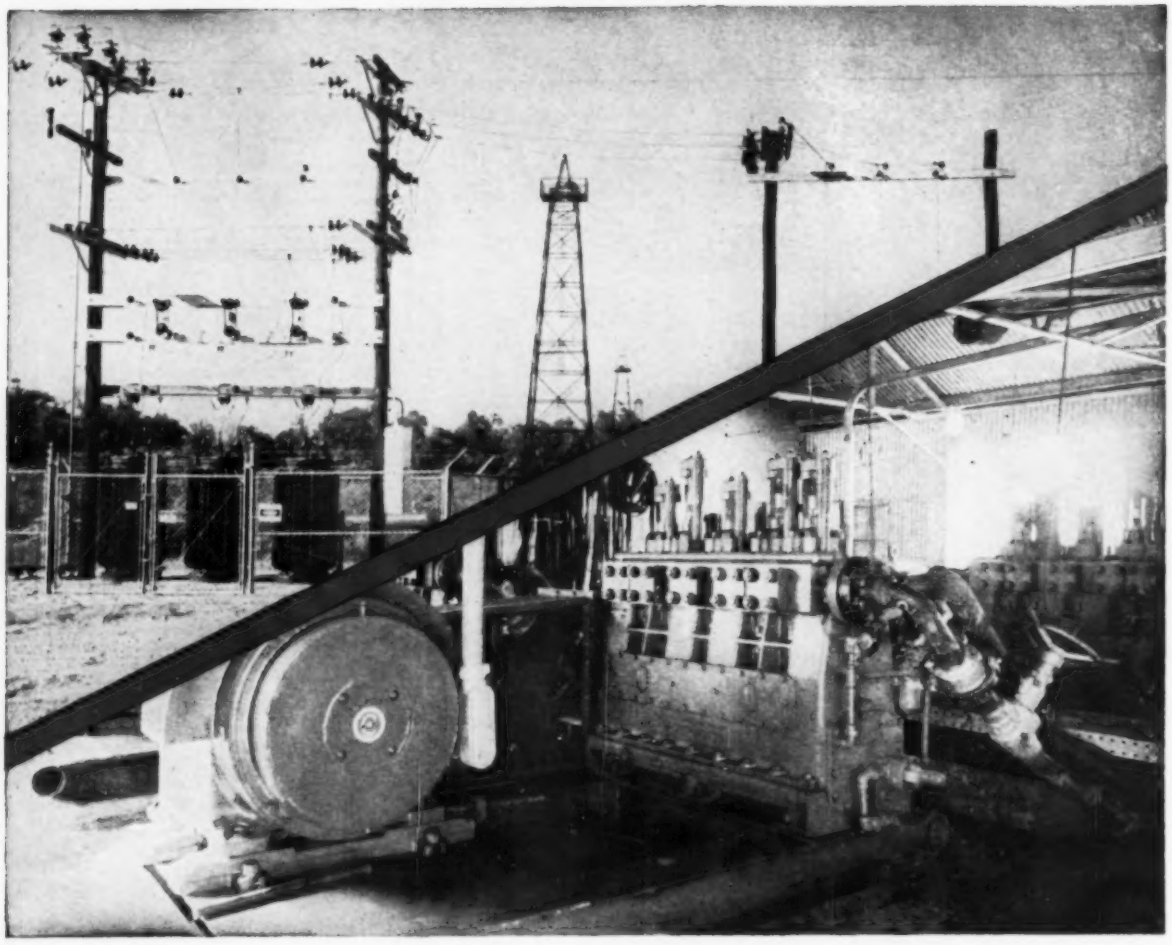
The Kendall Company, Polyken Sales Division


Reprints of Ralph Ballantine's picture, "Underground Highway," without advertising suitable for framing available at $1 from Polyken.
Ballantine

WATER FLOODING OPERATIONS ARE TURNING MORE AND MORE TO UTILITY ELECTRIC POWER



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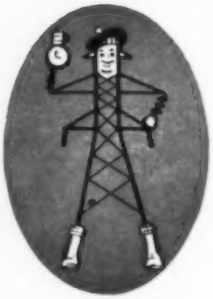

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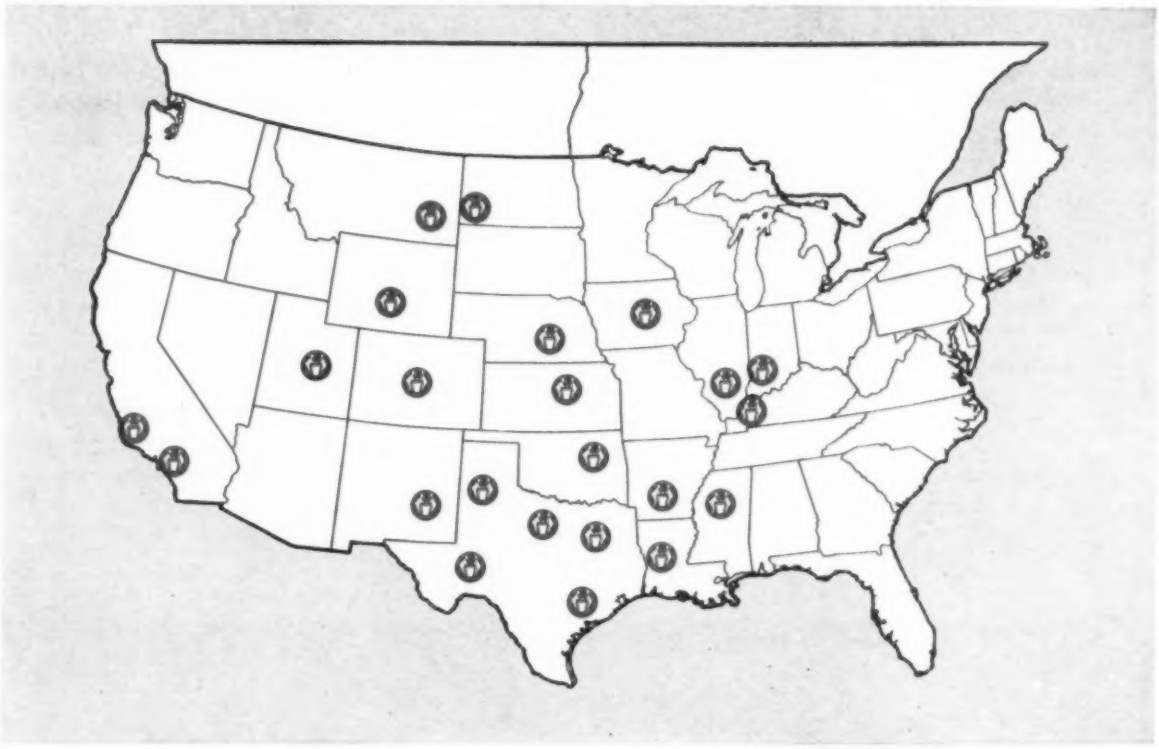

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GIVE US AN OPPORTUNITY TO SAY YES

put FIRST financing in your own oil future

Sold on past performance, Penrod powers its third drilling rig with CAT Diesel Engines

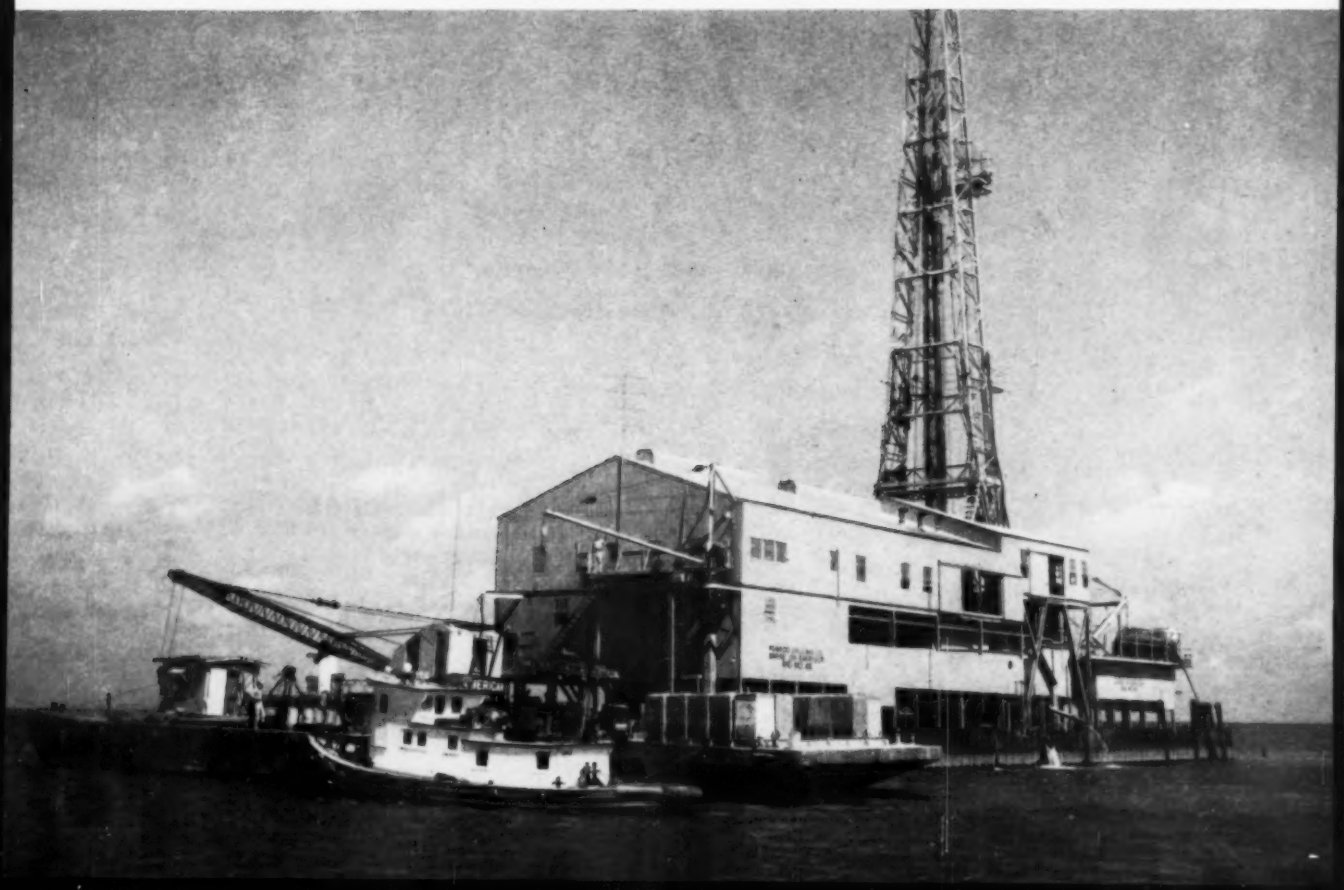
Penrod Drilling Co. of Shreveport, La., working Rig No. 45, fifty miles southwest of Houma in Cat Island Pass (on the southwest edge of Kye Island field) relies on Cat Diesel Engines in drilling better than 1,000 ft. per day. With four D397s, two D315s and two D342s, the "Jim Garrison" barge moved in on Sept. 14, spudded a 15" surface hole and set 3,029 ft. of 10¾ surface pipe. On Oct. 31, they were out of the hole to run electric log at 15,177 ft. and cut a 9⅞ hole on the first well. Their best drilling time was 10,026 ft. in 10 days from spudding date. More than 1,000 ft. per day.

On this offshore drilling operation, Penrod compounds three of its Caterpillar D397 Diesel Engines to drive the Emsco drawworks. Two D315s and a D397 drive Gardner-Denver mud pumps, and two Cat D342 Electric Sets handle auxiliary power.

A big operator and investor in dependable equipment, Penrod can't afford to guess about drilling power. This Company *knows* from experience that Cat Engines are reliably rated and are available in a variety of power sizes for any drilling assignment.

Only two of the many "guts" features which make Cat Engines the best for drilling are cylinder liners and pistons. To give long periods between overhauls, Cat Engine pistons are balanced to close tolerances. Cast-iron bands support the top rings for extra strength, and rings are chrome-faced for

Penrod Drilling Company's "Jim Garrison" Barge, powered by eight Cat Diesel Engines, has drilled at an average rate of 1,000 ft. a day on this job south of Houma, La.



longer wear. Piston rings ride freely with minimum wear because Cat cylinder liners are honed and chemically treated to give long life. Cat wet-type cylinder liners maintain low piston temperatures and are easily changed if necessary.

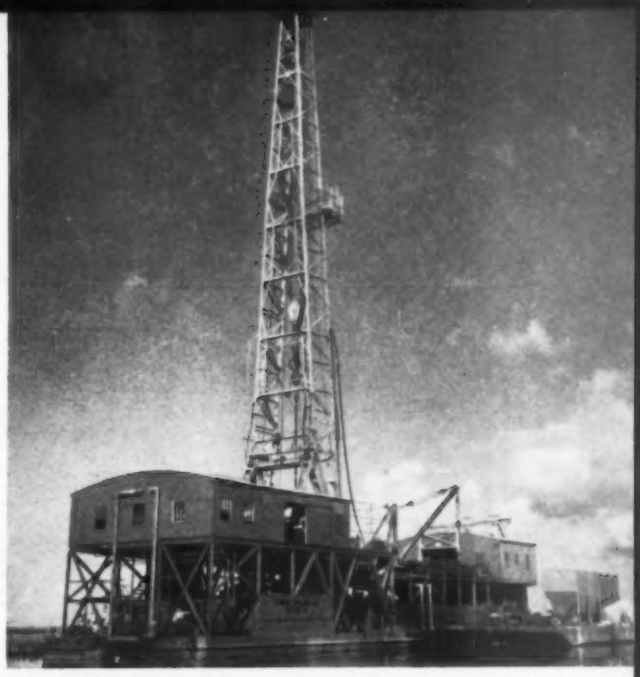
For drilling power—from prime to auxiliary—call your Caterpillar Dealer today. He's that real good neighbor—the one who knows what he's talking about. And be sure to specify Caterpillar power for your drilling equipment.

Engine Division, Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

DURABLE VALVES FOR LONG LIFE

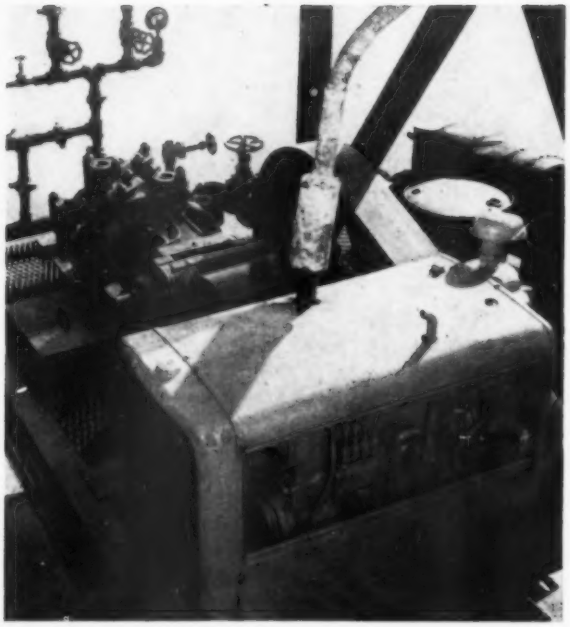
The Cat Engine's valve train features dual valve springs; sodium-filled, alloy steel valves; replaceable valve seats and guides; hardened cam followers; and valve rotators.

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

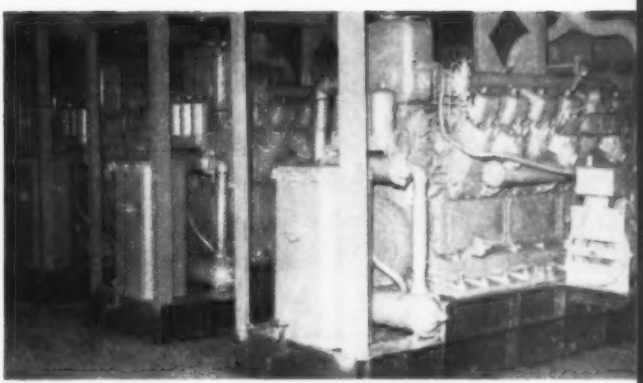


Penrod's Rig No. 41, drilling southeast of Port Sulphur, La., also is powered by Caterpillar. Two D397s are compounded to drive the drawworks, two additional D397s drive the mud pumps, two D315s drive Mission Water pumps, and a third D315 drives a Gardner-Denver water pump, with a Cat D315 Electric Set used for auxiliary power.

ENGINE POWER BY CATERPILLAR



This Caterpillar D315 Engine drives a water pump on Penrod's Rig No. 41 near Port Sulphur, La. One of many components which make Cat Engines dependable is aluminum precision-type bearings supporting the crankshaft. Each bearing has a thin coating of tin for proper bearing break-in for long engine life.



These three Cat D397 Engines are compounded to drive the Emsco drawworks on Penrod's Rig No. 45. Three additional Cat Engines drive the mud pumps and two Caterpillar Diesel Electric Sets furnish auxiliary power for the rig.

Dept. PE3, Engine Division
CATERPILLAR TRACTOR CO., Peoria, Illinois, U. S. A.

Send me more information about Caterpillar Diesel Engines for prime and auxiliary power in drilling operations.

☐ I would like detailed information, as I may be in the market for a Cat Diesel Engine or Electric Set. I understand I am under no obligation.

☐ I am interested in learning more in general about these engines.

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PEOPLE

Wolverine Tube. Ralph Seaton was appointed to newly created post of technical sales supervisor for this fabricating division of Calumet & Hecla, Inc.

Howard J. Luetzow was named technical sales representative to serve the New York, New England areas, to replace Seaton.

Mark A. Wallesz was appointed to fill Luetzow's position as technical sales representative in Chicago and surrounding areas.

The Wheland Company. William Earl Shorts, who for 25 years represented the company in Oklahoma oil fields, retired January 1. Shorts had earned from his associates the title, "Dean of Oil Field Servicemen." Lee O'Shields now represents Wheland as serviceman in Oklahoma City.

Welex, Inc. G. T. Armstrong has been named vice president and division manager of the newly organized Panhandle-North Texas division, Dallas. Other division personnel include J. E. Grady, assistant division manager and Weldon L. Porter, division sales manager, both in Dallas. C. W. Denny is a division sales engineer in Amarillo.

L. F. Drake was named division manager of the new Oklahoma division. Other division personnel include Harold Wolverton, assistant division manager; R. B. Burns, division sales manager; G. R. Short and G. K. Harcourt, division sales engineers, all of Tulsa, and J. W. Sherwood and G. C. Thomas, Jr., sales engineers in Oklahoma City.

Weatherford Oil Tool Company, Inc. Homer Longino has been appointed vice president in charge of sales and Bill Louderback will be assistant vice president in charge of sales. Longino joined Weatherford in 1954 as a sales and service engineer. He served as southern division manager with headquarters in Corpus Christi, Texas. Louderback has had oil field experience with Permian Mud Service and Superior Mud Company, joining Weatherford in 1956.

Robert O. Isham of Fort Worth, assistant finance officer, is new vice president in charge of finance in Edmonton, Alberta, Canada. Robert P. Turnbull was named vice president of sales in Edmonton.

Garland Diggs is the new southern division manager in Corpus Christi. Bud James, district manager in Beaumont, becomes assistant southern division manager.

Truman B. Wayne & Associates. Paul E. Nicholls, Jr. has joined the consulting firm as manager, refining and petrochemical services. He was associated with Gulf Publishing Company, Houston, since 1955 as maintenance and design editor, petroleum refiner and market research director.

United States Steel Corporation. T. D. Brissman is appointed manager of sales, Houston district office of National Tube Division. He succeeds the late James R. Boax. Brissman returns to the office where he started his business career, all with National Tube, 19 years ago.

Edward H. Pelster was named manager of sales of Tulsa sales office of National Tube Division. He succeeds Gerald F. Coons, retired. Formerly he was manager of sales of National Tube's Denver, Colorado, office.

John A. Hagan was appointed assistant to vice president — operations of United States Steel Corporation.

United States Rubber Company. E. Leonard Borg has been named manager of synthetic rubber development for the Naugatuck Chemical division.

Tube Turns Plastics, Inc. Donald A. Drake was named southwestern district manager for the new district sales office in the Southwest, with headquarters at Houston, Texas.

Stewart & Stevenson Services, Inc. Sam McCleneghan was appointed project engineer. He was one of the founders of the Valley Manufacturing Company in Valley, Nebraska.

Southern Pipe Coating Company. A. B. Aycock was named plant superintendent in charge of all pipe coating and wrapping work done in Doraville, an Atlanta suburb.

Security Engineering Company. Peter L. Winter has been named Eastern Hemisphere assistant sales manager. Based in London, Winter will be responsible for distribution of Security rock bits and other drilling tools to oil-active areas throughout the Eastern Hemisphere.

Schlumberger Well Surveying Corporation. W. A. Eickmeyer, for many years manager of the Abilene, Texas, district, is now division sales manager in Dallas. R. G. Tefft, formerly district manager at Andrews, Texas, replaces Eickmeyer at Abilene. New manager at Andrews is G. F. Horst. L. F. Holdman is the new sales engineer at Mt. Vernon, Illinois. Burton Delleney, formerly division sales manager in Dallas, was transferred to the Patent Department in Houston. V. J. Davis, formerly field engineer, has been promoted to sales engineer at Gainesville, Texas.

Charles A. Doh was named U.S. representative for foreign subsidiaries of the Schlumberger organization. Formerly, he was manager of customer relations for Schlumberger Well Surveying Corporation. Subsidiaries are Schlumberger Overseas, S.A., operating in the East and Far East; Schlumberger Surenco, S.A., operating in South America, and Societe de Prospection Electrique which is active in Europe.

Rust-Oleum. Thirteen Rust-Oleum factory representatives and their wives were awarded two-week all-expense paid trips to Nassau. Awards were presented by Robert Fergusson, president, at a sales meeting in Evanston, Illinois.

The Ruberoid Company. Phillip S. Bettoli was appointed director of research, replacing Clarence R. Eckert, who is retiring. He has been assistant director of research since 1952.

Roper Hydraulics, Inc. Joe R. Hames has been appointed district sales manager covering New Mexico, Texas, Oklahoma, Arkansas, and Louisiana.

National Supply Company. Marshal Alexander was named credit manager of its Midwest Division, with headquarters at division offices in Tulsa, Oklahoma. He succeeds J. M. Hone who has been assigned other duties.

Crane Company. William O. Brown, manager of west coast sales district, was appointed general manager of sales with headquarters at the company's Chicago general office. He will coordinate the plumbing, heating and industrial sales activities, as well as the marketing research and advertising-sales promotion departments.

J. W. Greene, vice president for sales, has resigned. Elected to the vice presidency in 1957 after 21 years of service in sales activities, Greene has been in ill health for several months.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

PROTECT & SEAL THREADED FITTINGS

Apply LED-PLATE Sealing & Anti-Seize Compound

Recommended for HYDRAULIC FITTINGS will not plug orifices

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Tight with less torque
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U.L. approved for butane, propane, gasoline, petroleum.
Use for: Hydraulic fluids, steam, ammonia, etc.

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Temperature range—100° to 2987° F.

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Stops rusting, acid-etch and corrosion.

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EASY DISASSEMBLY ANYTIME
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OIL WELLS PIPING

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Trade Parade

Davison Chemical Company. James B. Hattman was appointed district representative of Davison, division of W. R. Grace & Co., with offices in Tulsa, Oklahoma. He was formerly with Houdry Process.

Dow Chemical Company. John L. Sinclair, a veteran of 47 years' service and superintendent of the Midland division's well department from 1940 to 1956, has retired. He served the past two years as a consultant to the well department.

The Fluor Corporation, Ltd. Edmund C. Austin was appointed to the newly created position of director of purchases. He has 20 years of experience with Standard Oil Company of California and Arabian American Oil Company.

General Electric. Walter E. Sutter district sales manager at Redwood City, California, was advanced to national manager of microwave sales for General Electric's communication products department and will make his headquarters in Syracuse, New York. He will have responsibility for G-E microwave equipment sold to pipeline firms, utilities, toll road authorities and other types of users.

Koehring Company. Promoted are: A. V. Cossens, from assistant sales manager to the newly created post of product manager; Kensal R. Chandler, from service manager to assistant sales manager; George E. Schmidt, from field service manager to service manager; Donald Kilpatrick, to the new position of parts manager; Nicholas J. Decker, from works manager to general works manager; Robert Williams, from manager of cost reduction to manager at the Milwaukee plant; Peter Miles, from assistant foundry manager to foundry works manager.

DEATHS

Dr. V. A. Kalichevsky, 62, internationally known chemical engineer, author, and lecturer, and a consulting engineer at the Magnolia Petroleum Company, Beaumont, Texas, died February 3.

Carl J. O'Hornett, 75, dean of landmen and lease brokers, died during the week of January 11 at Tulsa.

Riley Elmer Andrew, 78, widely known oil drilling contractor, died January 10 in Nevada, Missouri.

Andrew K. Brumbaugh, 47, an assistant manager of the refinery engineering division of Socony Mobil Oil Company, Inc., and an employee of that company for the past 19 years, died January 10.

George D. Sheffield, 47, purchasing agent for New York Rubber Corporation at its general offices in Beacon, New York, died January 24 at Vassar Hospital, Poughkeepsie, New York.

Frank X. Gilg, 57, an executive assistant in the boiler division of The Babcock & Wilcox Company, died suddenly January 26 after a heart attack suffered at his home in Bronxville, New York.

Carlos E. Bronson, 71, former vice president and chief engineer of the Kewanee boiler division, American Radiator and Standard Sanitary Corporation, died at his home in Kewanee, Illinois, January 21.

John H. Merrell, honorary director of Raybestos-Manhattan, Inc., passed away January 4, at Chicago.

I. B. Hamilton, 39, chief paleontologist for Sun Oil Company, died in Dallas, Texas, following a short illness.

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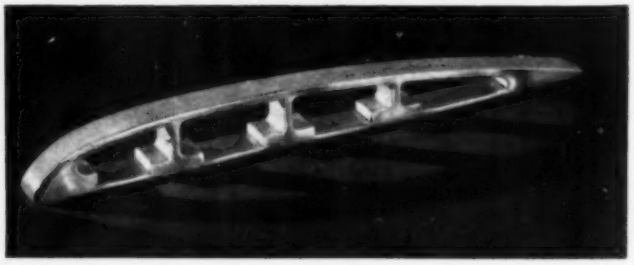

Cross section shows structural superiority of Aeromaster's new, extruded aluminum-alloy blades in diameters from 9' to 22'.

NEW! EXTRUDED ALUMINUM Blades on AEROMASTER* fans only

AEROMASTER'S new, extruded aluminum blades combine in one design the advantages of a light weight metal, a hollow structure and the superior strength of wrought metal . . . Silicon-magnesium aluminum alloys resist corrosion. Their fine grain structure, high tensile strength and increased endurance eliminate danger from wear, vibration, and metal fatigue . . . true airfoil blade sections assure maximum air delivery . . . adjustable blade pitch angle permits decrease of fan load to an accurate minimum horsepower requirement.

The AEROMASTER fan is easily assembled *in the tower.* No special handling equipment is necessary. AEROMASTER fans cost less to install, less to operate, less to maintain!

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Engineered Products Sold with *Service*

*Koppers Trademark

LAUGH with BARNEY

A rich bachelor girl made it a practice to invite several servicemen each week-end to her beautiful country estate. One week-end a good looking officer showed up alone. It was a case of love at first sight. The impact was terrific. As he was leaving he held her in a close embrace. Kissing her he asked, "Suppose, dear, after a few months you should find something was wrong — what would you do?"

"Why . . . why . . . I would shoot myself!"

He patted her on the back encouragingly, "atta girl," he said.

* * *

"Sam, you've been drinking for many, many years — why don't you stop?"

"What? And give up something I've got $50,000 invested in!"

* * *

There was a young fellow named Bound,
While mowing his lawn he was drowned.
It was dark when he fell to the bottom of
the well,
He couldn't tell his grass from a hole in
the ground.

Stay-at-Home-Wife: "Darling, how thoughtful! That hotel where you stayed during the convention sent me a beautiful blue night gown."

* * *

A small girl whose father is a judge often said she was Judge Brown's daughter when someone asked her name. Her mother thinking this might sound snobbish, told her not to make that sort of reply, but simply to say she was Dorothy Brown. Later, someone asked her if she was Judge Brown's daughter. She replied, "Well, I thought I was, but mother says not."

She was trying on a beautiful fur coat. "I wish," she said, "it were called something else besides broad-tail. My husband fancies himself a comedian."

* * *

"Now tell me," asked the personnel manager, "just why do you want to go to work for us?"

"Well sir," replied the applicant, "I got sick and went to my doctor. He gave me five pills and told me to take one after each meal. That was three days ago and I still have four pills left."

* * *

"How do you feel about girls?"

"Oh, I have several ways."

* * *

The conquerors of Mt. Everest stayed on top about 15 minutes. It proves men will not waste time if there are no women around.

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A-1 Operations Research and How It Works — *Gilbert C. Jacobus*

A-2 More Interest on Your Training Dollar — *Carl Mullins White*

A-3 Industrial Relations in the Oil Industry — *Ray O. Weems Jr.*

A-4 Instruments and Control Equipment Directory for the Petroleum Industry

A-5 How to Write Better Technical Articles — *John L. Kent*

A-6 What Makes a Man Work? — *A. Q. Sartain*

A-7 The Philosophy of Reading — *Ralph M. Besse*

A-8 Percentage Depletion — Hardly Anybody Understands It — *Ernestine Adams*

A-9 Management's Real Job — PROFITS — *Edward J. Burnell*

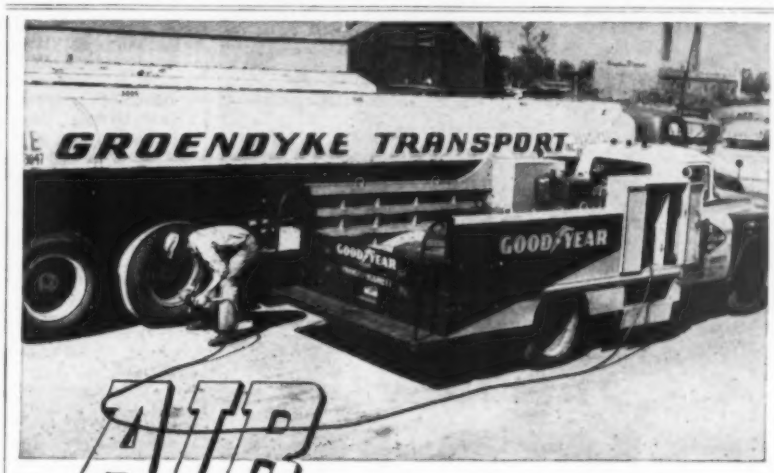
A-10 Canada Has Good Year — *H. G. Cochrane*

Name_____

Company_____

Address_____

State_____



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Mobile Compressor Unit

The large capacity truck-mounted compressor unit shown in the illustration servicing a tank truck, provides on-the-job AIR SERVICE for inflating tires, operating air wrenches and a complete line of pneumatic tools commonly used in oil field and pipe line operations.

In localities where newly developed oil pools are served by mobile tanks until definite capacity appraisals have been determined, as well as in oil fields now served exclusively by tank trucks . . . Wisconsin-powered mobile compressor units are *essential equipment.*

Parrott-Hodnett of Wichita and Hutchinson, Kansas, have built up their own unit which fits exactly the available space in their service car as shown here. A Model VF4 Wisconsin Heavy-Duty Air-Cooled Power Unit is direct-connected to a Quincy air compressor and the owner may also add a high pressure pump to this installation for injecting aqueous solutions of calcium chloride.

Again, Wisconsin heavy-duty engine power *fits the job and the equipment* to the best possible advantage. The user is sure of unfailing dependability, low cost maintenance and heavy-duty HIGH TORQUE Performance . . . backed by *fast service* whenever needed.

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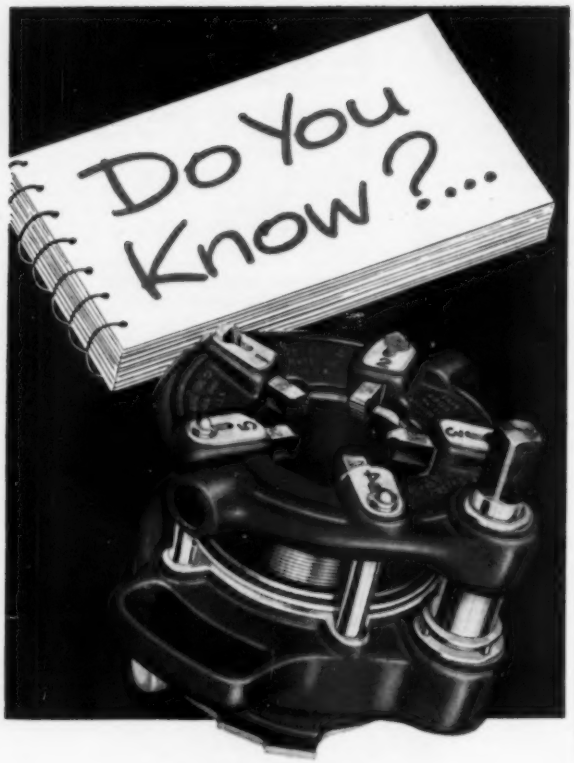

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4P-J

is the only 2½" to 4" geared threader that's Jam-Proof

It's safe—can't jam and knock equipment around when you thread pipe by power drive. Automatically kicks out after standard thread is cut. Workholder sets to size *before* putting on pipe—other easier work features. See it at your Supply House!

The Ridge Tool Company

Elyria, Ohio, U.S.A.

A Guide to Books

Automation and Management, *by James R. Bright, published by Division of Research, Graduate School of Business Administration, Harvard University, Boston, 1958. Pages, 270 Price, $10.00.*

Since the petroleum industry is one of the most automated industries, management needs always to be alert to purpose, methods and experience in automation. Professor Bright has directed his study to the problems created by automation. First he gives a background of the nature of automatic operations, then deals specifically with experiences of mechanization describing automation programs of 13 plants. He reviews the critical areas of automation in which he sums up the significant trends of automation and their effects. The task that automation imposes on management and the attitude and philosophy that should underlie the managerial direction of automation programs are discussed. The book has an appeal both to policy-making management and to operational management.

How to Sell and Unsell Ideas, *by Fred DeArmond, published by Lloyd R. Wolfe, Chicago, Illinois. Pages, 222.*

In "How to Sell and Unsell Ideas," Fred DeArmond tells you how to convince a prospect or a customer, a jury, a friend, a board of directors, a civic or business group — any audience of one, 10 or a 100 persons.

DeArmond is not concerned with the matter, but with the manner of conducting a controversy — what to say, how to say it, and how to make your point stick. He draws upon his own vast experience, as well as upon reams of research material, taken from accounts of the great controversialists of history. He does not stop with merely quoting; he dissects and analyzes their style, strategy, techniques; he spotlights successful methods.

Every one of the 18 chapters is outlined for quick reference — every chapter is concluded with a capsule summary. An appendix lists all source material for further research, if desired.

Higher Oxo Alcohols, *by Lewis F. Hatch, published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York City 16. New York. Pages, 120. Price, $4.50.*

While considerable emphasis is placed on the oxo process for the manufacture of higher alcohols, the major purpose of the book is to present and discuss the utilizations of the various products. Higher oxo aldehydes also come under consideration. Uses described include plasticizers, agricultural applications, detergents, lubricant additives, and synthetic lubricants. Properties and chemistry are presented in adequate detail for the text to be valuable to chemists and sales engineers.

Polyethylene, *by Theodore O. J. Kresser, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22. New York. Pages, 217. Price, $4.95.*

Kresser's book is the first in Reinhold's Plastics Applications Series. It deals with standard applications of polyethylene along with some unique uses that solved rather puzzling problems. Almost half of the text is devoted to background, properties, chemistry, manufacture, and processing of polyethylene. It would be of value, therefore, to people in any phase of the plastics industries.

Chemistry of Natural and Synthetic Rubbers, *by Harry L. Fisher, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22. Pages, 280. Price, $6.50.*

Covers almost all phases of the rubber industry, from the raw material stage up to — but not including — final fabrication of products. As the title states, major emphasis is placed on chemistry for the major types of rubbers. Receipts, tables, and photographs add to its utility, as do special chapters devoted to bonding of rubber to metal and chemical derivatives of synthetic rubbers.

1957 Structure Maps of Texas Oil Fields, *published by Rinehart Oil News Company, Box 1208, Dallas, Texas. Pages, 260. Price, $17.50.*

This reference book contains 251 map exhibits as submitted during the past year to the Texas Railroad Commission for rulings on field discoveries, injection projects, and Rule 37 Permits. The material, representing all exhibits suitable for reproduction, is arranged alphabetically by counties, by districts, and bound into a single conveniently indexed volume. Each map is identified according to county, district, producing formation, contoured interval, and type hearing.

Electrostatics in the Petroleum Industry, *by A. Klinkenberg and J. L. van der Minne, published by Elsevier Publishing Company, Amsterdam, Holland.*

Static electricity has been recognized for many years as a serious hazard in the oil industry. Time and again there have been mysterious explosions whose cause was subsequently traced to static electricity.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

The Royal Dutch/Shell Group of companies has recently undertaken research of some considerable scope to throw further light on this phenomenon. They have carried out much experimental work in full-scale equipment. The electric effects produced by such operations as pumping, mixing and aircraft fueling were closely investigated. It was proved that an explosion can be induced solely by high-speed pumping of a gasoline-water mixture into a tank.

Considerable information was gained about generation and dissipation of static electricity. A practical means has been found to overcome the problem of static electricity in petroleum products.

In view of the wide-spread interest in the safety aspect of this subject Shell has decided to make their final research and development report available to the industry.

▸ **Phase Relations of Gas-Condensate Fluids — Test Results, Apparatus, and Techniques,** *published by the American Gas Association, 420 Lexington Avenue, New York 17, New York. Pages, 439. Price, $10.*

A new book has been published by the American Gas Association, describing fundamental research conducted by the Bureau of Mines, U. S. Department of the Interior, in cooperation with the American Gas Association, culminates 20 years of study of fluids in high-pressure reservoirs. The publication is Volume I of a two-volume monograph. Fundamentals are reviewed in one of the eight chapters, test results are reported in five of the chapters, and two chapters are devoted to correlations. Chapters in Volume II, now in preparation, will pertain to correlations of test results.

▸ **Ira Rinehart's North Texas Reference Books,** *Vol. 4 and 5, published by Rinehart Oil News Company, Box 1208, Dallas, Texas. Pages: Vol. 4, 269; Vol. 5, 268.*

Distribution of two new reference books — one volume covering the development history of 335 fields in Montague, Wichita, and Wilbarger counties, Texas, and a volume reporting the same type of information on 375 fields in Wise and Young counties of Texas. The two books are the fourth and fifth in a series of five North Texas Area reference books published during 1957.

The set includes maps, electrical logs, completion histories, and production statistics on some 1592 individual oil and gas fields located in Texas Railroad Commission District No. 9.

▸ **The Making, Shaping and Treating of Steel,** *seventh edition, published by United States Steel Corporation, Office Service-Stores, 525 William Penn Place, Pittsburgh 30, Pennsylvania. Pages, 932. Price, $7.50; student's price, $5 (with signature of instructor).*

Completely revised since its sixth edition was issued in 1951, the new volume offers users and makers of steel a comprehensive summary of present-day theory and practice covering all phases of iron and steel production.

The new edition is the result of team effort by nearly 200 technical representatives of U.S. Steel, its operating divisions and subsidiaries, co-ordinated by H. E. McGannon, technical editor, under the direction of Dr. E. C. Bain, assistant executive vice president-operations.

The book contains 773 illustrations and 126 tables, and is divided into 50 chapters, which are subdivided into sections.

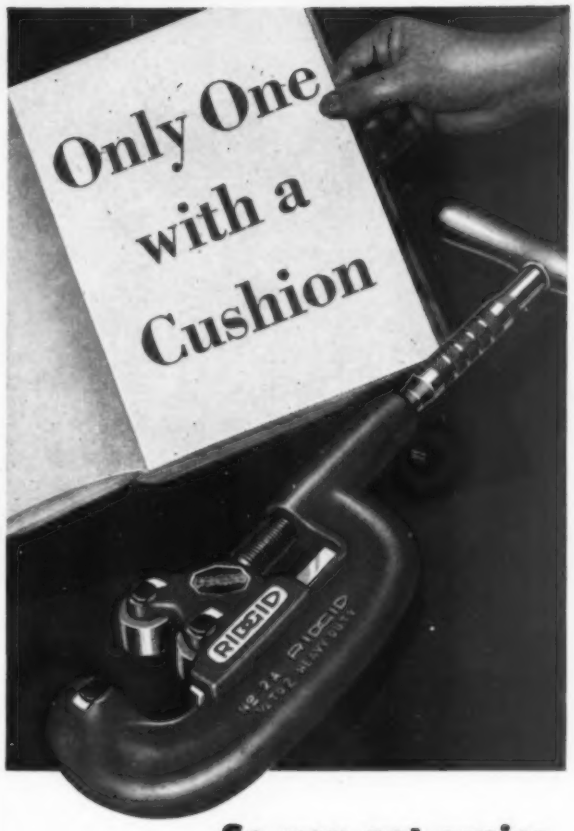
▸ **Engineering Materials Handbook.** *Edited by Charles L. Mantell. McGraw-Hill Book Company, New York. Pages, 1936. Price, $21.50.*

The handbook covers metals, organic and inorganic materials, and the cause and prevention of failure of materials in 43 sections. Virtually every usual and unusual engineering material is included, with emphasis on fabricated forms, physical and mechanical properties, adaptations, advantages, limitations, corrosion, and proper care and maintenance. Prepared by more than 150 contributors.

▸ **Directory of Geological Material in North America,** *second edition, by J. V. Howell and A. I. Levorsen, published by The American Geological Institute, 2101 Constitution Avenue, NW, Washington 25, D. C. Pages, 208. Price, $3.*

This volume, which follows a first edition printed in 1946, will find ready approval of geologists throughout the U. S. and Canada for it contains references for source material and data on almost any subject relating to the field of geology. It, like its predecessor, lists sources of broad geographic and topical scope, a section listing in detail sources of information available in each state or province. Many sources of interest to geologists in mining and other branches of science have been added to this volume.

Complete addresses of state and federal bureaus, sources for maps, air photos, cross sections and guide books, drillers and electric logs, scouting and drilling reports, well cuttings and cores, well elevations, water well records and control and lists of publications, libraries, book dealers, and museums. A section is also included on selected bibliographies and books.



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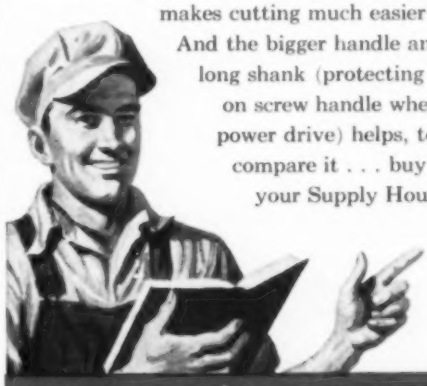
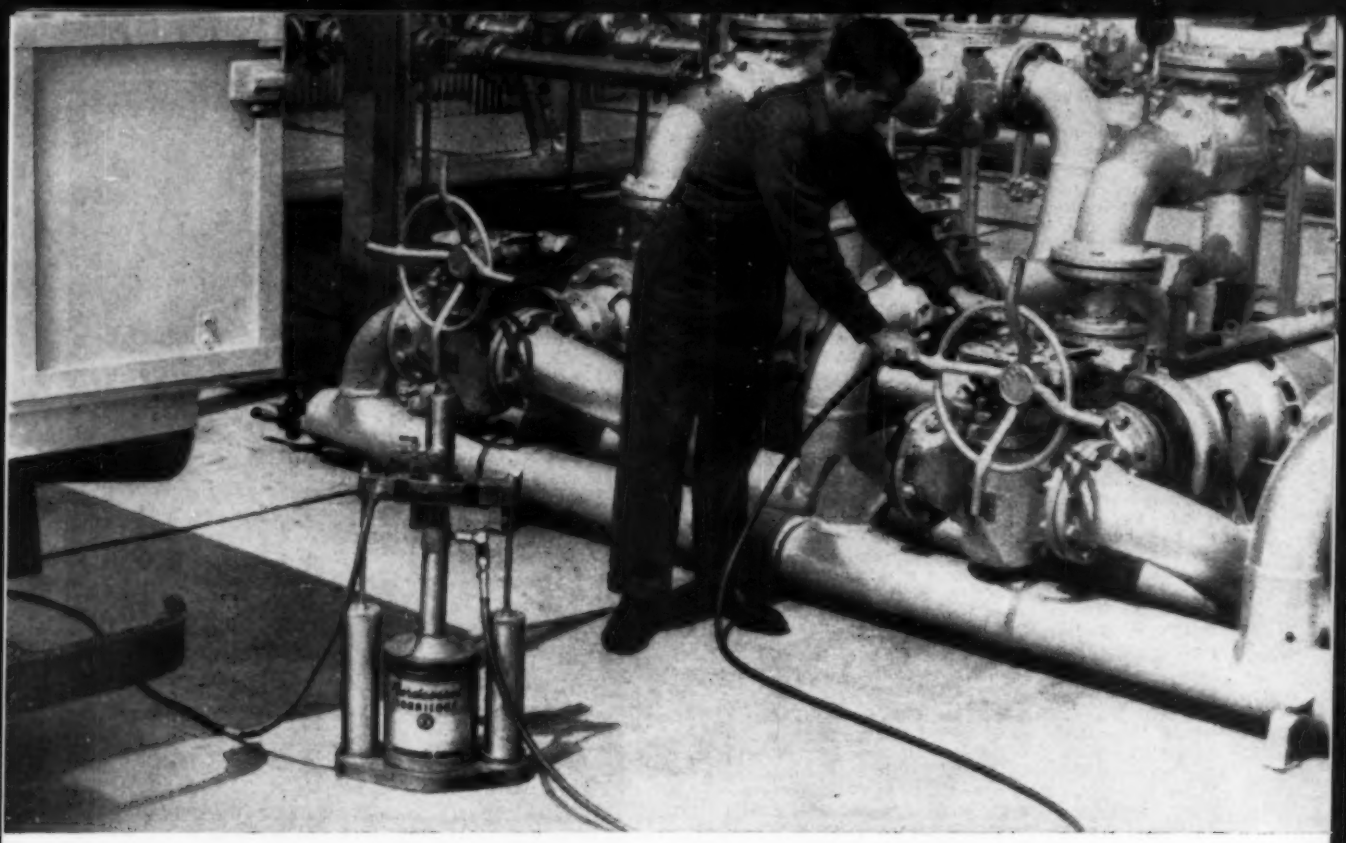
Heavy-Duty Pipe Cutters

The instant you start feeding in this new cutter on a pipe you feel the remarkable difference, the new cushioning effect that makes cutting much easier and faster. And the bigger handle and extra long shank (protecting threads on screw handle when you use a power drive) helps, too. Try it, compare it . . . buy it at your Supply House.



The Ridge Tool Company, Elyria, Ohio, U. S. A.



How valve lubrication

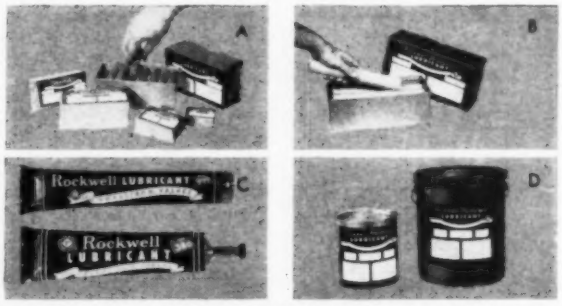
SAVES MONEY

For over forty years, operation cost studies have proved that Rockwell-Nordstrom lubricated plug valves perform better, yet cost far less to use, than ordinary valves. Here's why:

THE FUNCTION OF LUBRICANT is not just to make operation easier, but to form a leakproof, positive seal between the plug and valve body. Pressurized lubricant in the Sealdport grooves is actually a kind of "soft seat" that is instantly replaceable . . . it can't be *permanently* cut, worn or scratched like metal seats. Addition of new lubricant to a Rockwell-Nordstrom valve is like reseating an ordinary valve but it costs pennies instead of dollars.

Lubricant has another *very* important job in a Rockwell-Nordstrom valve. Acting as a "hydraulic" jack the pressurized lubricant provides a means of instantly unseating and freeing the plug . . . even after years in an open or closed position.

In any mechanism with moving parts, lubrication prevents wear and reduces friction. That's why Rockwell-Nordstrom valves work easier, stay in service longer and cost less to use. The information that follows shows equipment that will help you lubricate your valves more efficiently and at lower cost.

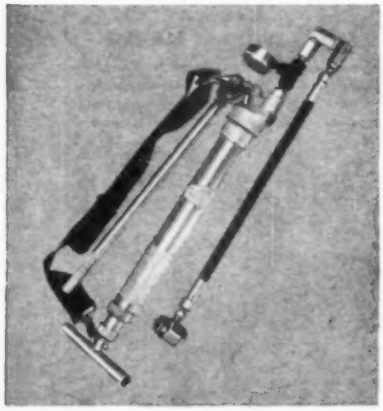


WORLD'S MOST COMPLETE LINE OF LUBRICANTS. Rockwell is the largest and oldest manufacturer of lubricated plug valve lubricants. Each lubricant is a result of painstaking research and careful field testing. A complete list of lubricants and the services for which they are recommended is available . . . use the coupon on the facing page.

The lubricant types illustrated above are (A) Stick Lubricants for manual insertion. (B) Stick Lubricants for lubricant guns, for fast, easy lubrication through the Rockwell fitting on the valves. (C) Gun Tubes for fast refilling of lubricant guns and convenient bulk tubes (spout type) for individual valve lubrication. (D) Bulk Lubricants in five quart and five gallon pails.

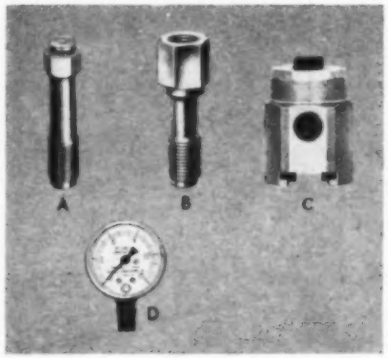
HAND LUBRICATION of a few small valves is done easily by unscrewing the Rockwell fitting with any standard wrench and inserting Rockwell stick lubricant. Screwing down the fitting creates proper lubricant pressure.

ROCKWELL HIGH PRESSURE HYDRAULIC HAND GUN is used at installations similar to those recommended for the booster gun. The Hydraulic Gun develops much higher lubricant pressures with less manual effort making it suitable for lubricating larger valves.



ROCKWELL BOOSTER HAND GUN provides high pressure lubrication for small or medium sized valves at installations where a moderate number of valves are to be maintained. Quickly loaded with stick lubricants, the hand gun is fast, easy to operate and insures proper lubricant pressure within the valve.

ROCKWELL HYPREGUN saves time and labor at large valve installations especially where there are numerous large valves. The Hypregun is a compact, self-priming air operated lubricant bucket gun. Using 5 qt. pails of lubricant, it's easy to properly service the largest valve installations.



LUBRICATION ACCESSORIES. Just a few of the lubrication accessories available from Rockwell are shown above. The Rockwell Fitting (A) is now standard on all valves. The drilled and tapped lubricant screw (B) makes a convenient fitting for use with pressure gauges or gun fittings. The Rockwell 400 giant button head coupler (C) has a built-in shut-off to eliminate lubricant extrusion from residual pressure in the hose (the "400" is standard on all Rockwell guns and pumps). Pressure gauges (D) for hand guns and bucket pumps tell *automatically* when correct lubricant pressure is reached . . . also indicate when valve needs further gland adjustment.

How to Select Rockwell-Nordstrom Valve Lubricants

Complete details on the proper lubrication of Rockwell-Nordstrom valves and the proper lubricant formula number for a wide range of services are detailed in Rockwell Bulletin V-220. Generally, the following information is vital to the selection of the proper lubricant:

1. Precise description of the line material to be valved.
2. Temperature range to which valve will be subjected.
3. Pressure range within which the valve will work.
4. Size and type of Rockwell-Nordstrom valves.
5. Frequency of operation.
6. Type of lubricant (stick, gun tube, pail or bucket) to be used.

Rockwell's lubricant research staff will be pleased to give special attention to operating problems not specifically covered in the literature.

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Pittsburgh 8, Pa.

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Six choices of corrosion resistant tubes and sockets

4130 alloy steel tube with alloy steel tip and socket.

403 stainless steel tube with alloy steel tip and socket.

403 stainless steel tube with 416 stainless tip and socket.

316 stainless steel tube with alloy steel tip and socket.

316 stainless steel tube with 303 stainless tip and socket.

Monel tube with alloy steel tip and socket.

Tubes and sockets listed above are available in Type 100 Mastergauges which are designed for extreme service and pressures. Type 101 Mastergauges, for medium and high pressures, are available with:

4130 alloy steel tube, with alloy steel tip and socket.

403 stainless steel tube, with 416 stainless steel tip and socket.

403 stainless steel tube with alloy steel tip and socket.

STAINLESS...from socket to tip

Another Marsh development! The superlative Mastergauge is now available with stainless and alloy steel bourdon tubes. Try to find a corrosive service that isn't covered by range of materials listed above.

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Photo shows result of laboratory test in which gun cartridge was discharged in rear compartment of Safecase. Thin, tough back yields to abnormal pressure, but cannot be dislodged by blowout. Front of gauge remains intact, protected by heavy metal barrier.

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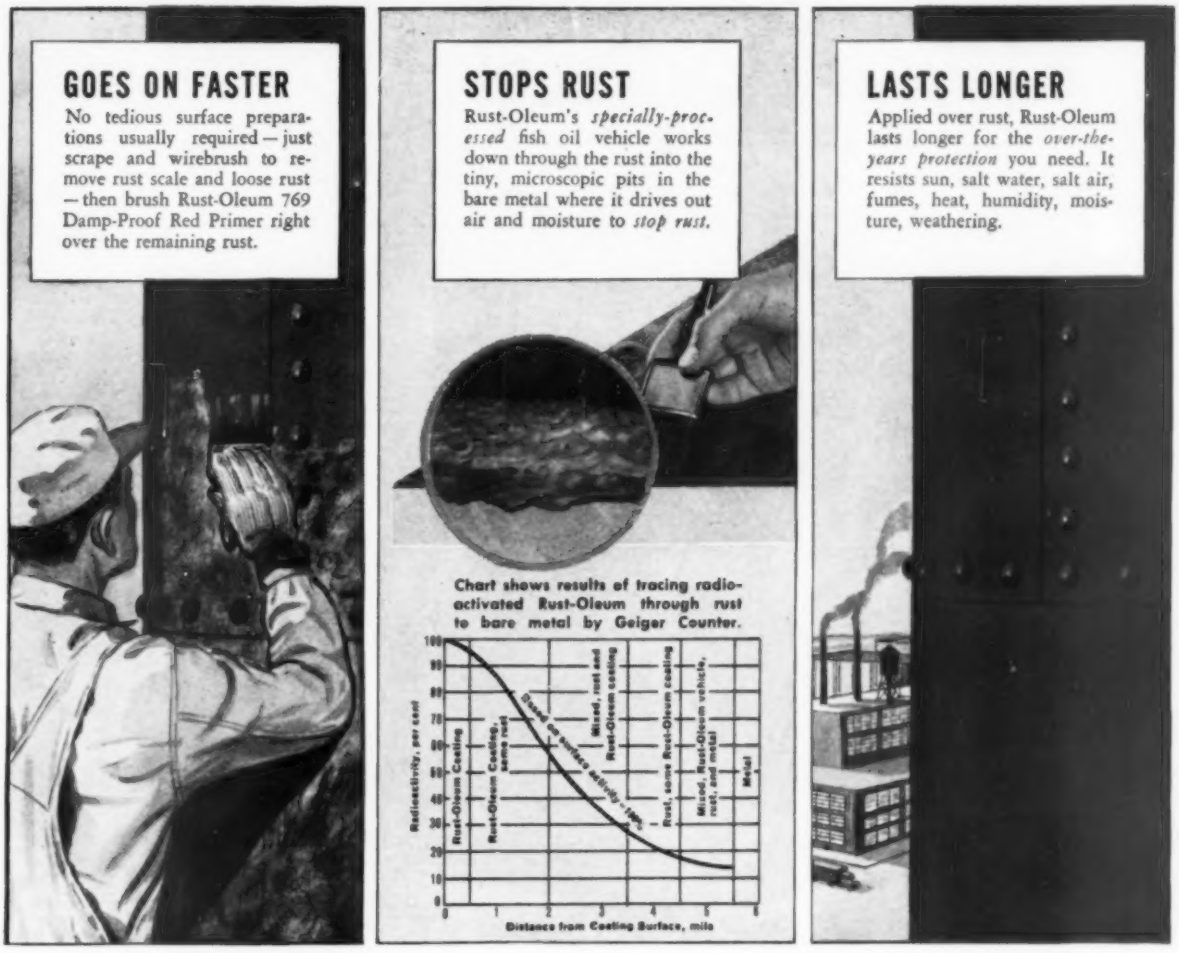
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Rust-Oleum Coating, some rust
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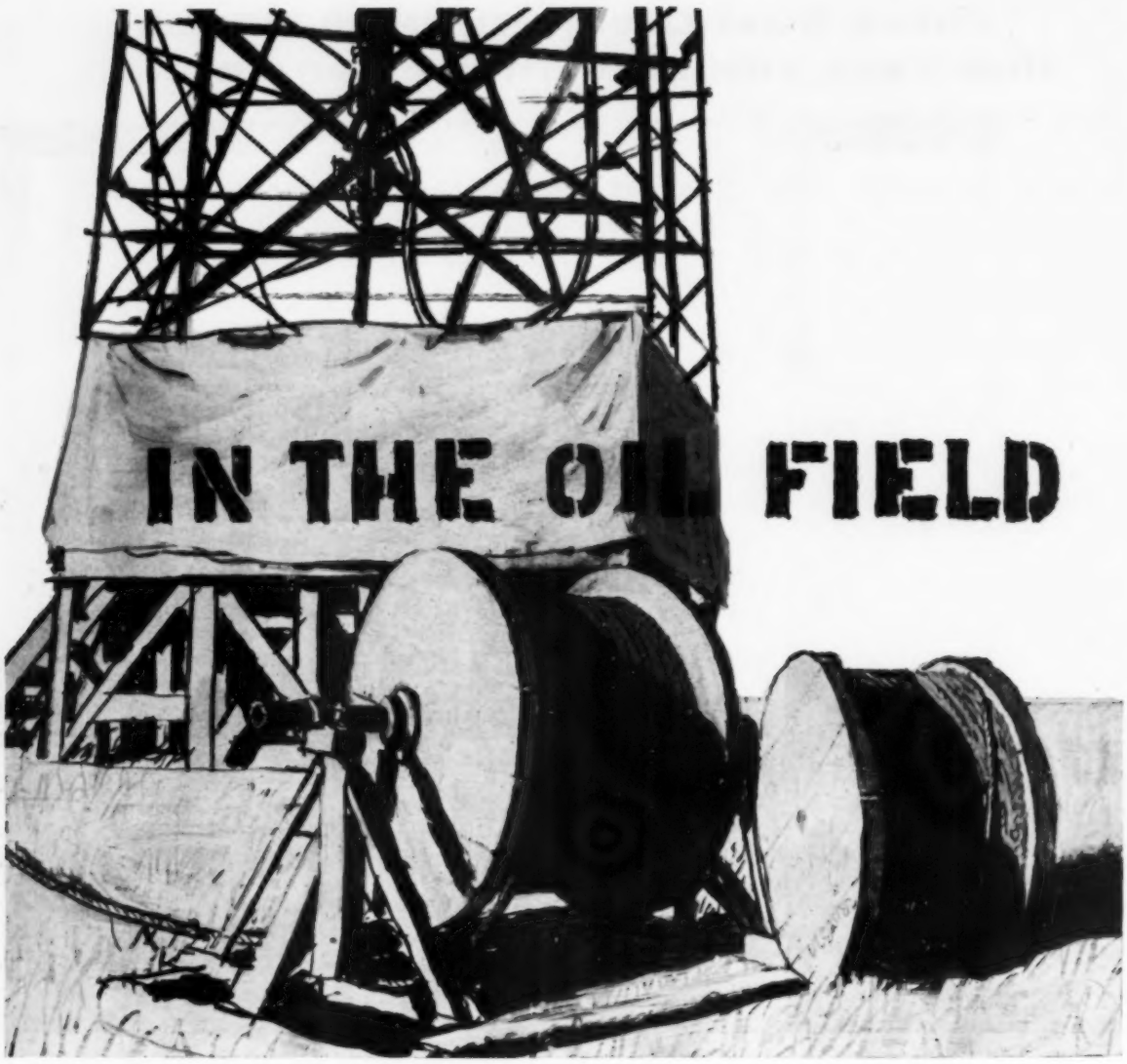

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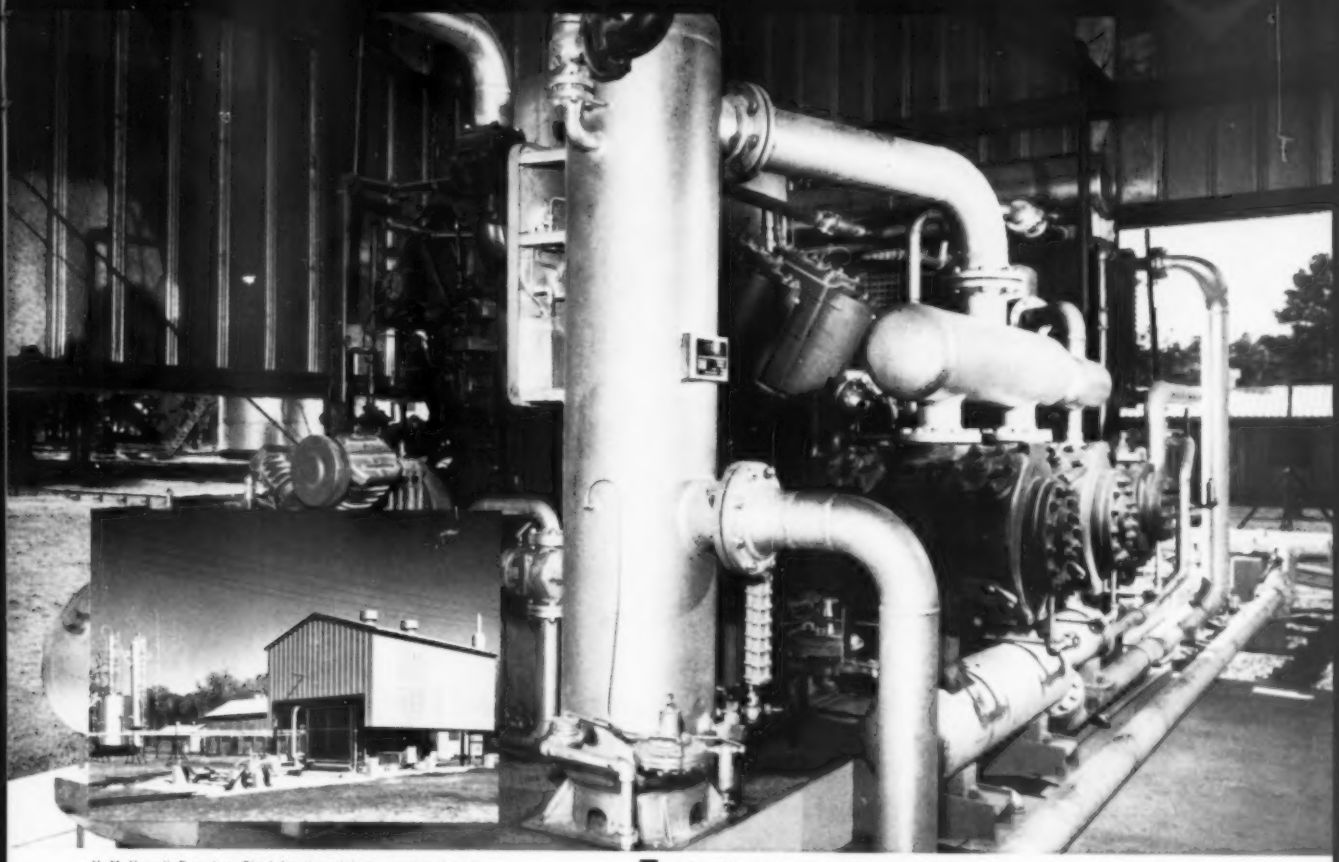

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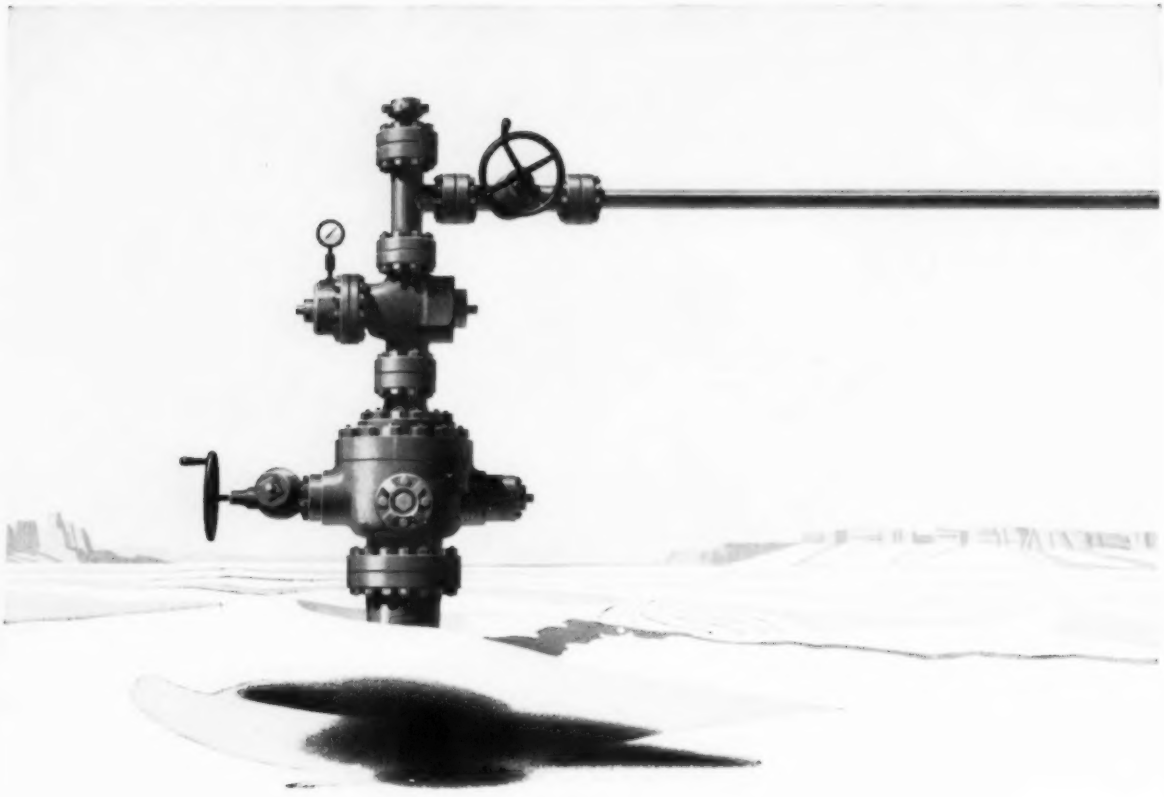

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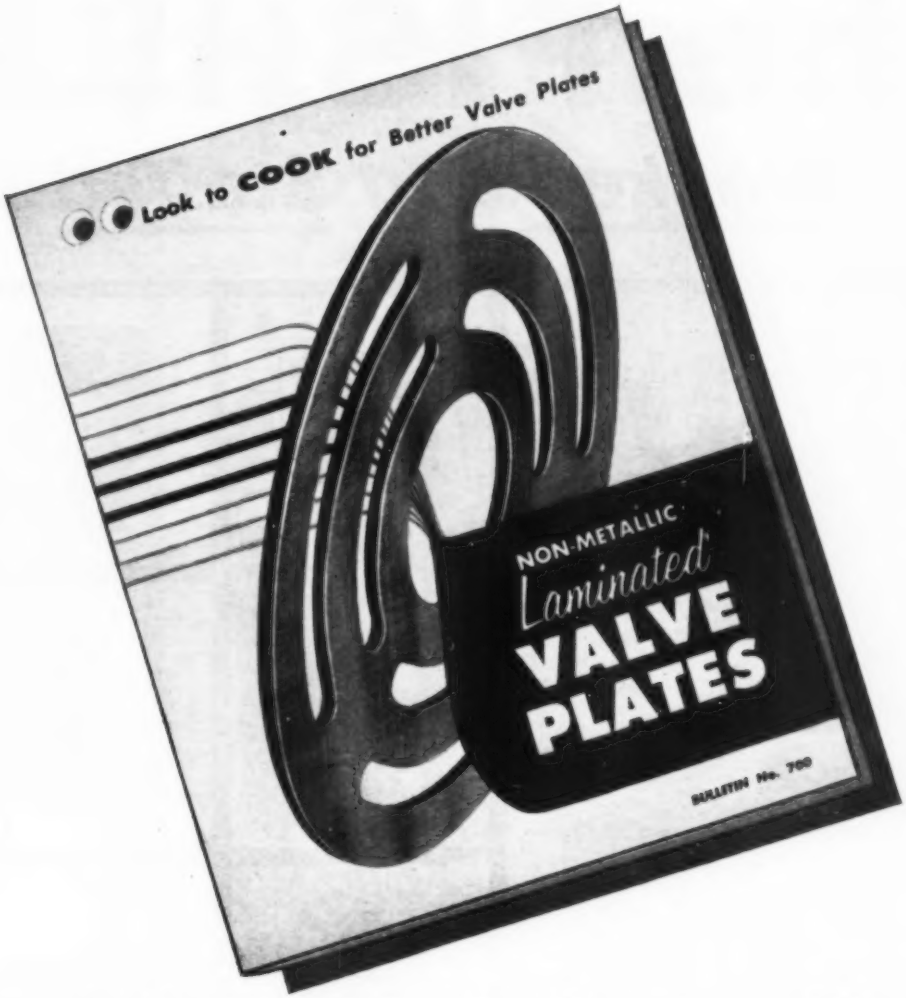

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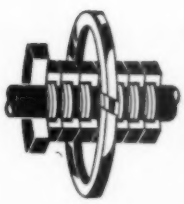

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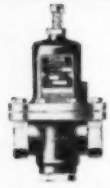
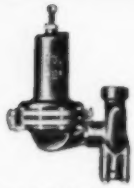
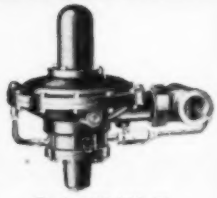


Type 95-H Pressure Reducing Valve



Type 630 "Big Joe" Field Regulator



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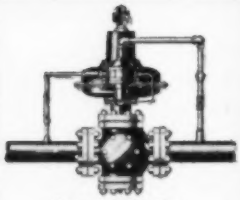

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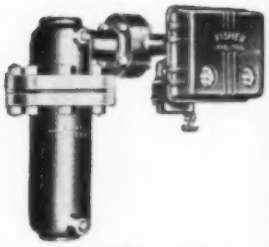

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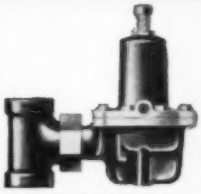

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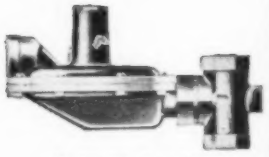

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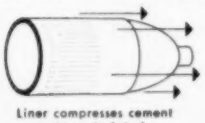
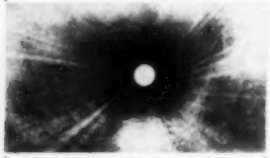


Liner compresses cement mortar onto interior



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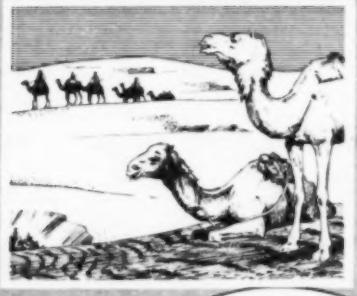

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In Operation Two Weeks

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Must have two or three years experience in pipeline work.

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A major integrated U. S. Oil company operating in Venezuela has outstanding career opportunities for qualified RESERVOIR ENGINEERS. Excellent growth possibilities are present in an expanding technical organization. Graduate engineers and physicists who have had FIVE to TEN years of specialized and general petroleum reservoir engineering experience are invited to submit a complete resume of work experience and personal data. Naturally, all replies will be held in confidence and interviews arranged for qualified candidates. Salary, including bonus, $14,900-$18,000, depending on qualifications and experience. Company is a leader in the petroleum industry with excellent employee benefits, including home vacations with travel expenses.

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Kennametal API Balls and Seats are available at repair shops of most major pump manufacturers. Ask your service man to standardize on them. They'll cost you less in the long run. KENNAMETAL INC., Latrobe, Pennsylvania.

*Kennametal is the Registered Trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

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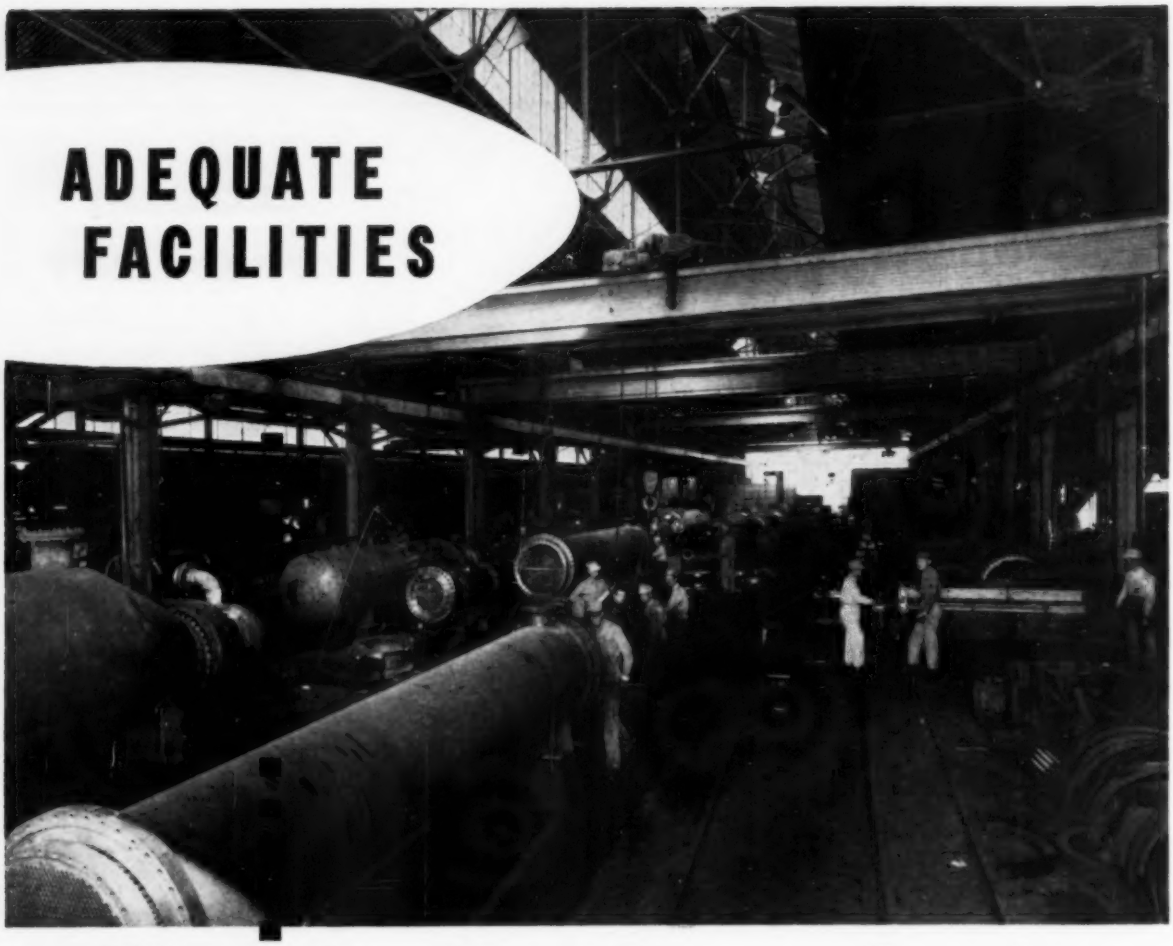

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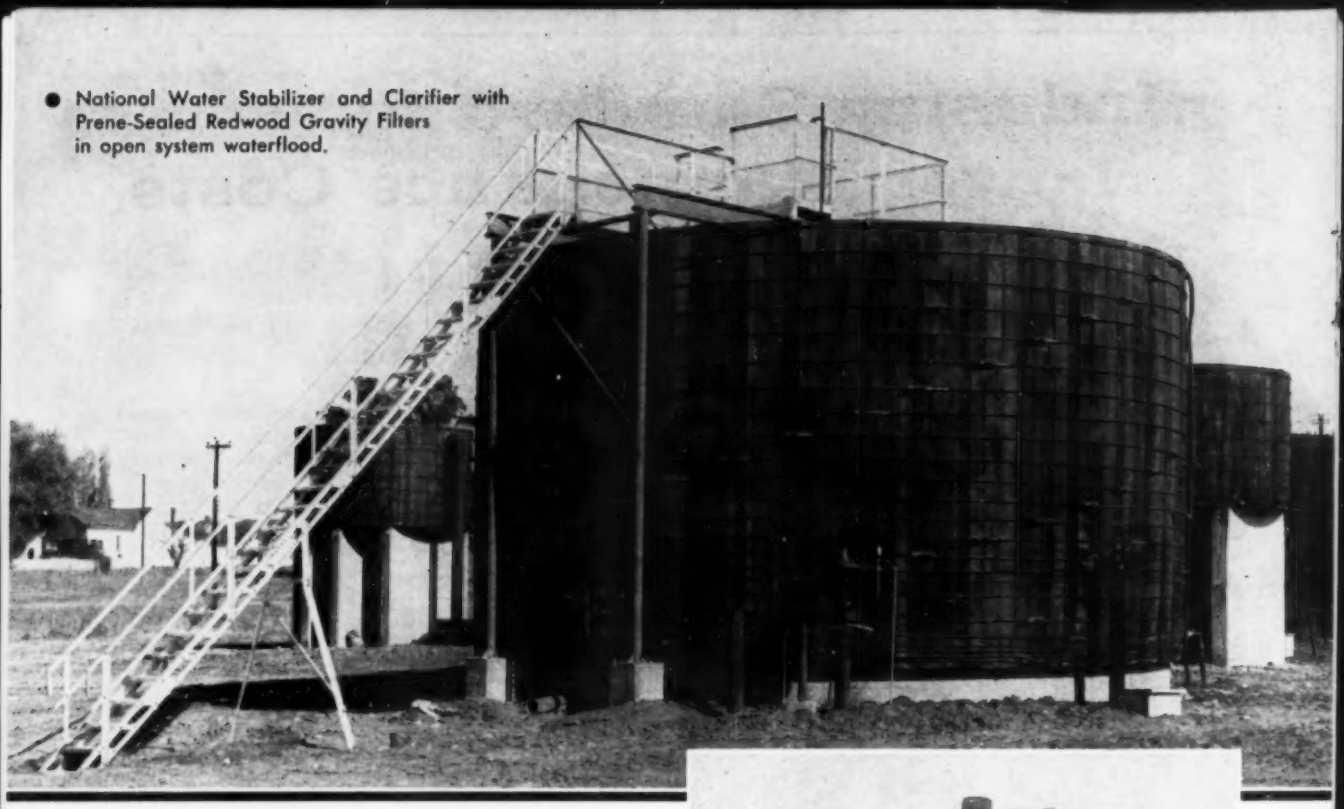

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National's Raw Water Stabilizer and Clarifier is designed for rapid and thorough chemical treatment of disposal or flood water, through circulation of slurry followed by short relatively motionless periods to permit settling of precipitants. Sludge is drawn off automatically through a valve at the bottom of the tank. The result is a stabilized clear water being delivered to the filters. Volume of water to be treated determines the size of the Stabilizer and Clarifier since a particle of water remains approximately two hours in the tank. The Unit is available in Bolted Steel Tanks, Prene-Sealed® Redwood and Rezo-Glas® Plastic Tanks. Internals are available of hot dipped galvanized after fabrication or Rezo-Glas non-corrosive plastic material, or steel with special coatings.

These units are available in a wide range of capacities and sizes from over 50 Warehouses in the United States, Canada and Venezuela.

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24' x 16' National Water Stabilizer and Clarifier with chemical building.

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Exploration
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Good equipment

MAKES Higher Profit

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When competition is roughest it is more important than ever to have good equipment operated by good crews. You do a better job for customers and keep your units busy. This reflects in your bank book.

Franks well servicing and workover rigs are just such equipment.

Rig-up is faster with a telescoping derrick that moves strung-up, raises hydraulically, is simple to level, and guys to the unit.

The air lift transfer provides speed in pulling, and stacking affords protection to rods and tubing. See a Franks representative or write for details on the various Rocket models 6,500 to 12,000 ft.

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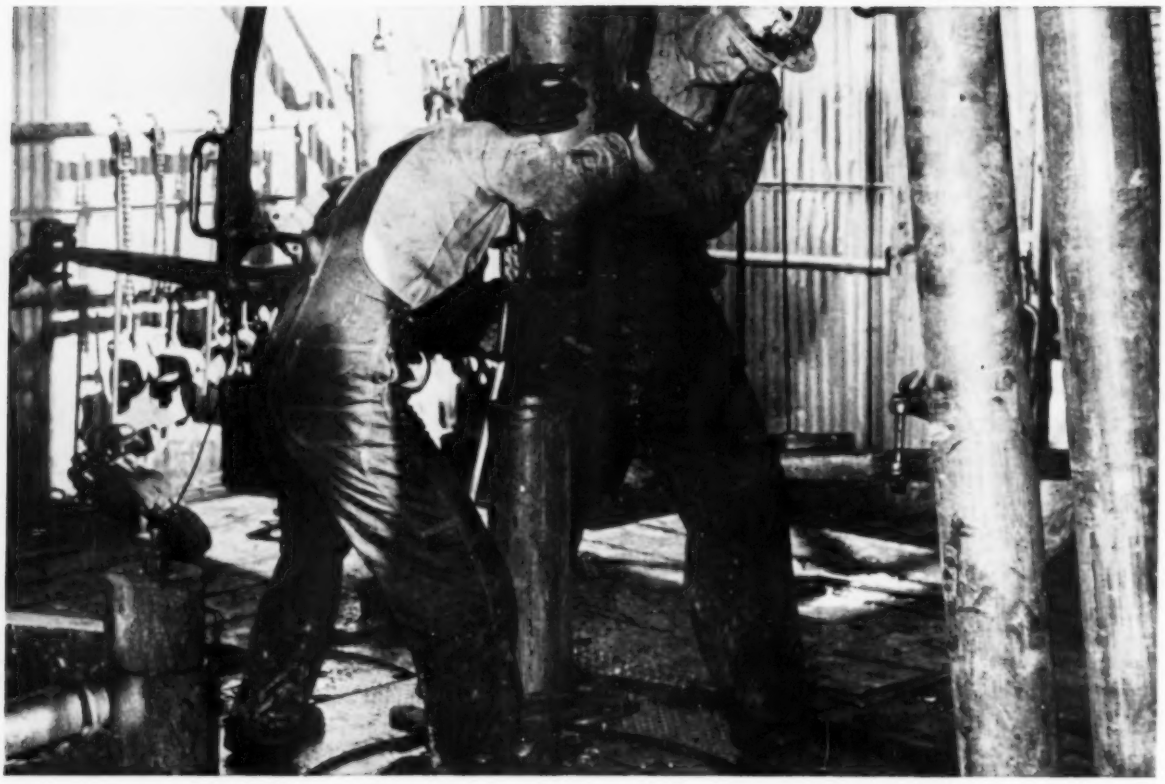

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Our metallurgists check and accept from the mill only those bars of uniform micro-structure which meet the high specifications for American Iron PREMIUM drill collar steel!

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Of Things To Come . . . In Oil

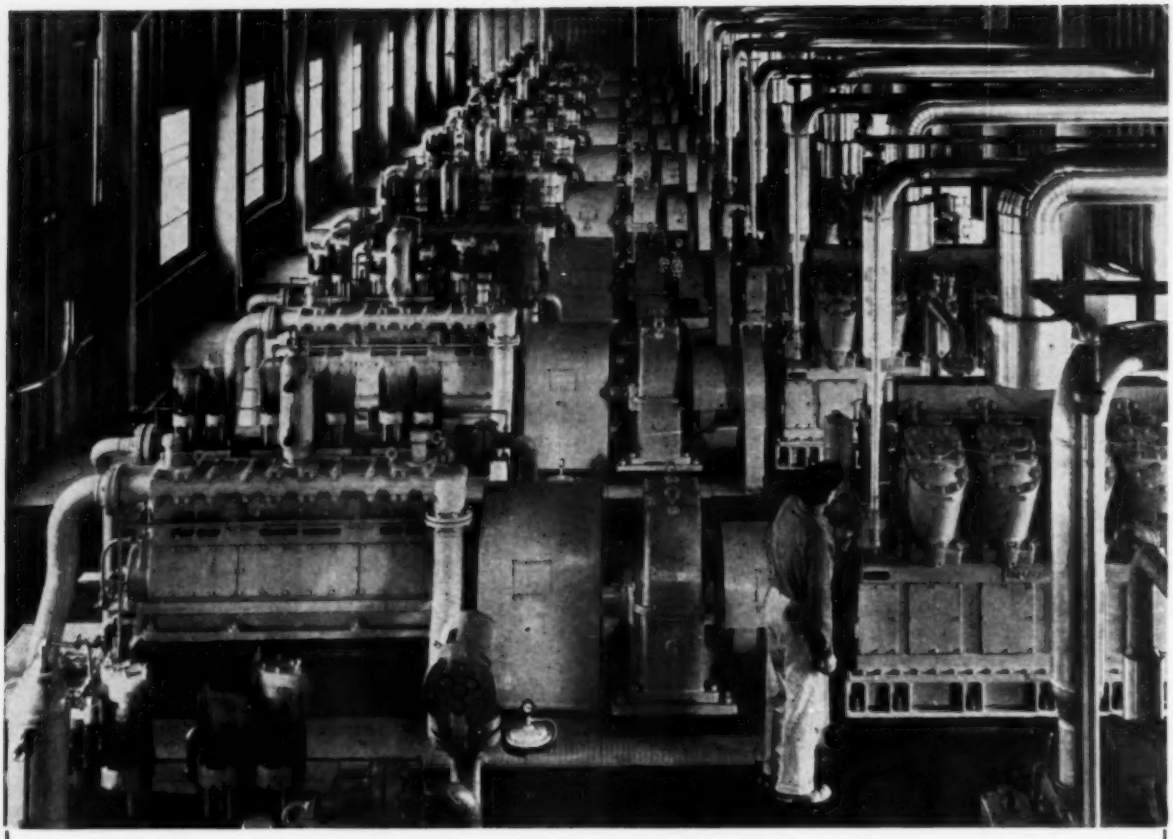
FOUR CORNERS CRUDE BUYING "INEQUITY" will get worse before it gets better. Distress situation began when purchasers requested crude to fill new Four Corners pipeline from northwest New Mexico and southeast Utah. Utah began fill averaging 175 bbl per well; New Mexico prorationing allowed only 11 bbl per well. New Mexico is having its internal problems, too — northwestern wells producing at the 11 bbl rate and southwestern NM wells producing 37 bbl per day. West Coast purchasers now are hinting that excessive crude stocks in California may choke up this line before operations actually begin.

"MODERATE EXPANSION IN ACTIVITY should take place, from this point forward," says Dresser Industries executive vice president R. E. Reimer, adding "domestic oil and gas industry's operations are at a low point for the year." He hopefully predicts that drilling will improve throughout the balance of 1958. Jack A. Vickers, president of Vickers Petroleum, however, forecasts continuing period of adjustment that could "include a series of setbacks" extending into third quarter of the year. He spoke primarily for the Mid-Continent area.

LOUISIANA MUST BE 6 OR 7 TIMES MORE SUCCESSFUL in next decade if it hits necessary oil finding target of 6 billion bbl of oil and 40 trillion cu ft of gas of new reserves, declares Bouwe Dykstra, vice president of Shell Oil Company's New Orleans exploration and production area. If the gap between income and outgo of capital ($1,000,000 a day) can be narrowed, says Dykstra, then offshore oil can provide its share of the nation's need for 3 to 3½ billion bbl of new oil per year.

ROYALTY PAYMENTS FOR UNION WORKERS? O. A. Knight, head of the Oil, Chemical and Atomic Workers Union, has given the oil industry warning that he will ask for improved fringe benefits in spring contract talks — which may include royalty payments on production. Money received would go to a union "royalty" fund as a savings and emergency fund with each employee credited with his pro rata share. Knight says "it would be an opportunity to share the benefits of automation." Spring labor talks will stress fringes rather than higher wages.

WELLS TO BE DRILLED IN 1958 may be slightly less than in 1957 — nearly 53,000 — but stress will be placed on field development, not wildcat drilling. Spot checks of small and large operators in Southwest indicate larger expenditures for "inside locations" in proved areas, and less appropriated for wildcatting. Larger independents, however, will continue semi-wildcatting — especially in Gulf Coast.



FIELD REPORT

FLOOD: North Ward-Estes Unit

PUMPS: 10 Aldrich Septuplex

FLOODING STARTED: December 1954

EXPERIENCE TO DATE:

Pumps operate constantly — 168 hours per week. There have been no breakdowns ... customer reports installation highly satisfactory ... "Maintenance actually has been less than we expected."

Field parts stock available in Carmi, Ill., Charleston, W. Va., Houston. Los Angeles, Odessa and Tulsa. For further information, write the Aldrich Pump Company, 26 Pine Street, Allentown, Pa.

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Tests are the proof of performance in a new product and the key to improvement in existing designs. This is why we have always considered test facilities to be an integral, working part of our design development program. But tests to be effective must not only simulate working conditions, they must also produce extremes for the study of equipment in unusual circumstances. In our test areas, actual oilfield conditions are stepped up beyond normal working limits to prove a point in design. Presently we are testing seven inch preventers for working pressures of 15,000 psi and ten inch preventers for 10,000 psi. Extremes in pressure, temperature and various phases of mechanical stress give the direction for designs to more than meet tomorrow's demands in any oil producing area. Innumerable tests of this type are part of Cameron's continuing design development program. Just such dedication to advancement has

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The S. M. Jones Company ADVANCED ENGINEERING, EXPERIMENTATION AND CONTROL

Year after year, for over 65 years, Jones engineers have solved problem after problem and have kept Jones Sucker Rods the standard of comparison. But the policy of the Jones engineering department is never to be satisfied, never to rest on laurels already won.

To this end Jones engineers have the use of a large fund of accumulated practical knowledge gained from years of laboratory and field tests. Thus Jones customers are assured of the earliest possible use of definite improvements.

The Jones engineering department keeps a tight control throughout all operations from raw stock to the finished sucker rod. Laboratory testing for correct alloy content and physical properties, after proper heat treatment, assures Jones using only the best steel completely free of defects. Controlled normalizing and tempering results in a microstructure which is uniform throughout.

There is no substitute for Jones experience and thoroughness in engineering, experimentation, and control. The continued leadership of Jones Sucker Rods is proof of that.

Above: All A.P.I. working gages are checked daily with master A.P.I. gages which are periodically certified by the National Bureau of Standards, Division of Metrology. Control like this insures uniformity of threads.

Left: Resistance to impact of heat treated sucker rod stock and experimental alloys is studied with this Izod-Charpy impact testing machine.

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difference in sucker rods

TYPE 8
JONES
alloy
SUCKER RODS

For extremely heavy pumping loads.

This rod is the result of long research and field use to produce the very best rod for exceedingly heavy pumping. It is made of special alloy steel of exceptional yield strength and well-balanced physical properties.

Specify Jones Sucker Rods for proved longer life.

FOUR TYPES OF JONES SUCKER RODS FROM WHICH TO CHOOSE

Type	Identification	USE	DESCRIPTION	PHYSICAL PROPERTIES					
				Yield 1000 psi	Ultimate 1000 psi	% Elong. in 8"	% Red. of Area	Izod	Brinell Hardness
J-12	Protector ends painted BLUE	For heavy pumping loads under all conditions	Made from processed electric furnace steel with high yield strength and excellent fatigue resistance.	95-105	110-125	12-17	65-75	90-110	229-269
J-8	Protector ends painted BLACK	For extremely heavy pumping loads	A special alloy steel of exceptional yield strength and well-balanced physical properties.	100-115	120-135	10-15	50-60	65-85	248-288
J-7	Protector ends painted ORANGE	For medium to heavy pumping loads under all conditions	Called "standard of the industry". Strong, corrosion resistant nickle molybdenum steel, fully normalized, tempered, descaled and shot peened for further fatigue and corrosion resistance.	85-90	85-100	14-22	60-70	90-107	170-210
J-2	Protector ends painted WHITE	For medium to heavy pumping loads in non-corrosive fluids	High grade carbon manganese steel, fully normalized, descaled and shot peened to add strength and endurance.	60-75	90-105	18-24	60-70	60-90	168-210

Jones Pony Rods carry the same physicals as Jones Sucker Rods. Always use proved superior Jones Pony Rods with proved superior Jones Sucker Rods.

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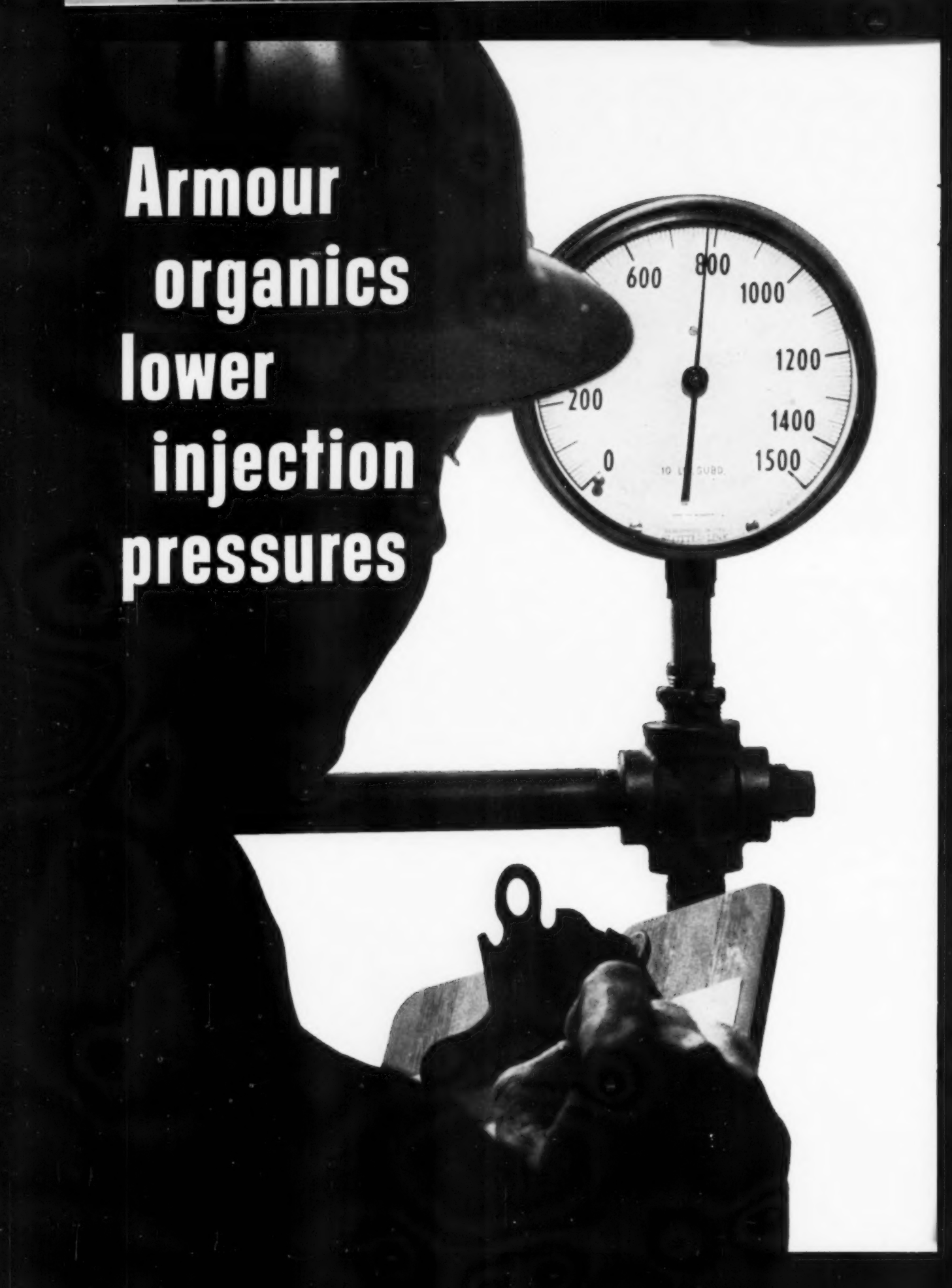
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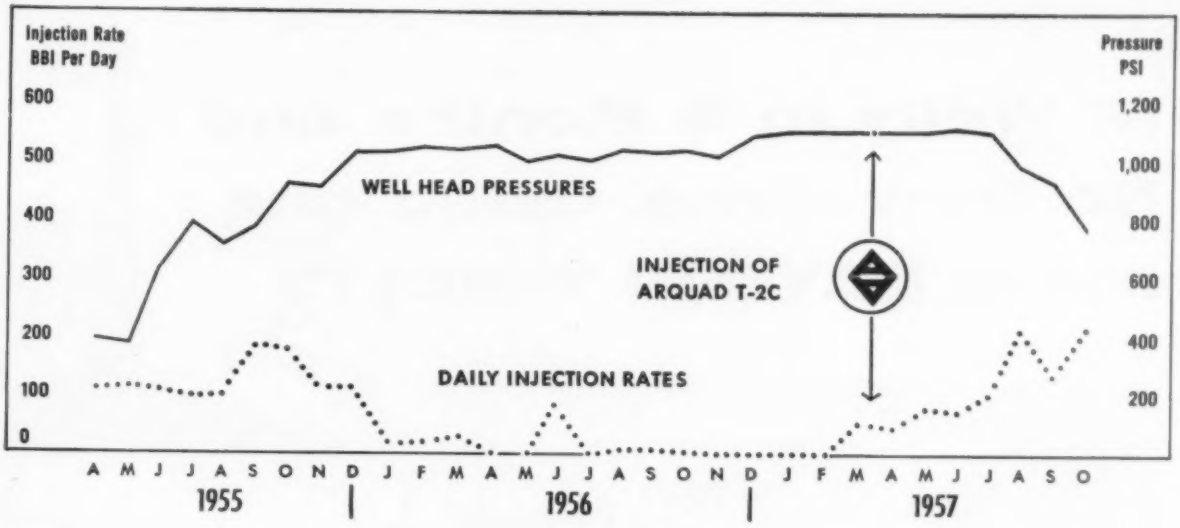

Well head injection pressure down from 1100 to 780 pounds, injection rate up from 30 to 220 bbls. per day at eastern Oklahoma water flood. This performance chart offers recent, conclusive proof how an Armour organic, Arquad® T-2C, makes possible more efficient oil recovery.

Armour organics stop corrosion—control bacteria. And by lowering surface tension of water they increase injection rates and decrease pressures for more efficient oil recovery!

Armour water-flood chemicals Armac® CD-50, Arquad® 12-50 and Arquad® T-2C are being used to lower injection pressures. These polar organic surfactants produce a detergent effect in water that apparently "scrubs" more residual oil from sand surfaces, often resulting in increased oil recovery.

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In many water floods, the action of Armour cationics have prevented scale deposits. The detergent and bactericidal effects of Duomeen® CD-50, Armac CD-50, Duomeen CDA-50 and Arquad T-2C have improved back-washing efficiency of all types of filters. The use of these chemicals ahead of the filters increases filter efficiency—especially diatomaceous earth filters.

For more than 8 years Armour chemicals for oil production have been used in oil fields all over the world. The most successful water-flood units are today using Armour cationics for *complete* bacteria control and as high as 99.5% corrosion protection. Through the years these same chemicals have demonstrated their ability to lower injection pressures, making them of even greater value to the oil industry.

For further information, send the coupon below.

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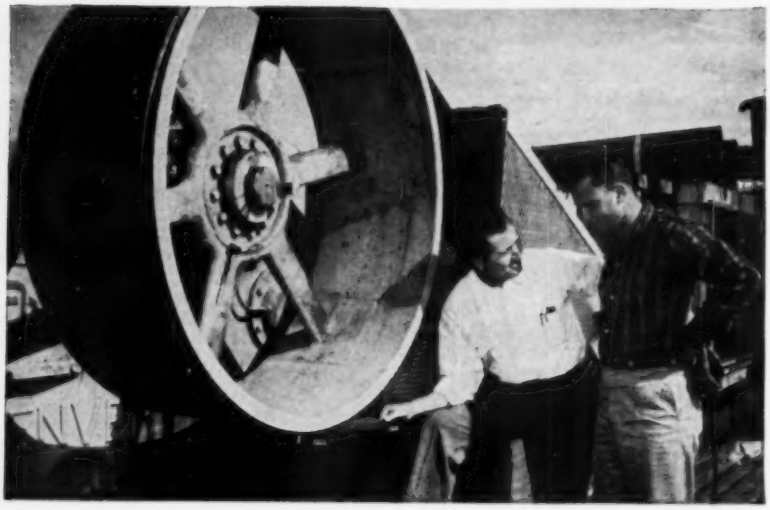
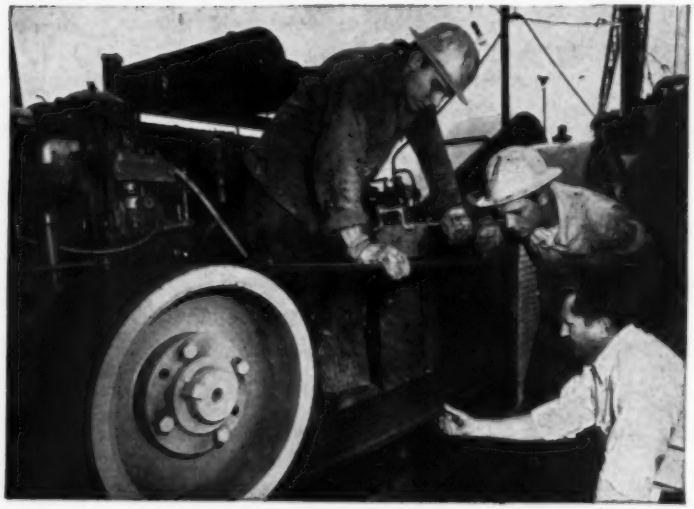
12 Wells in 8 Months and No Downtime, using one set of DAYTON V-BELTS



Jack Gresham, Toolpusher on Big Six Corporation's Rig # 2, says, "8 months ago, we switched to multi-matched Dayton Super-Thorobred V-Belts. Since then, Rig #2 has been on 12 jobs—sinking holes that averaged 9,000 feet in depth. In over 5000 hours of drilling, with the mud pump operating at 1800 psi, Dayton V-Belts have never caused one minute's downtime." Mr. Gresham is shown at the right, talking to Dayton Representative Werner Zapp.

"Because they're unaffected by oil, heat, moisture and static build-up, Dayton Super-Thorobreds resist every destructive condition we've found in our drilling operations. For instance, we were over-tensioning our former V-Belts to compensate for slippage due to belt stretch. Using surer gripping Dayton Super-Thorobreds, with their extra strength cord section, we can slack off the tension while maintaining full power. That way, we let the belts soak up shock and vibration that was transmitted to the pump.

"Dayton believes in service, too. Our Dayton Distributor in Houston, is backed up with a large warehouse stock. Thus, we get the belts we need, have them multi-matched and at the rig in half an hour."



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Insist on Dayton Multi-Matched V-Belts

Dayton Rubber

World's Largest Manufacturer of V-Belts

DAYTON RUBBER COMPANY • INDUSTRIAL REPLACEMENT DIVISION • DAYTON 1, OHIO

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With Magcobar on your well ...

you get full laboratory backing wherever you drill

"Get this sample to the laboratory as fast as possible." And by fast plane or car, the mud sample, packed in an air-tight stainless steel container, is rushed to the Magcobar laboratory. The laboratory works on a 24-hour basis when the emergency is your well. You get the precise information needed to keep drilling.

In many problem wells there is simply no way of obtaining the data needed for proper action at the well site. For example, you can't check for all chemical ions by simple titration, but with the spectrophotometer the right answer can be arrived at in minutes. In the laboratory complete chemical analyses of the mud can be made quickly and the physical properties studied at various pressures and temperatures.

This is the emergency work the laboratory does, backing up and supporting the field engineer. Just as important is its day in and day out job of developing new drilling chemicals, evaluating their effectiveness in the field, helping you in many ways to cut drilling costs through an engineered mud program.

Wherever you drill you benefit from the Magcobar Laboratories. So, make sure you get the best. Plan with Magcobar on your next well.

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DRILLING MUD SERVICE

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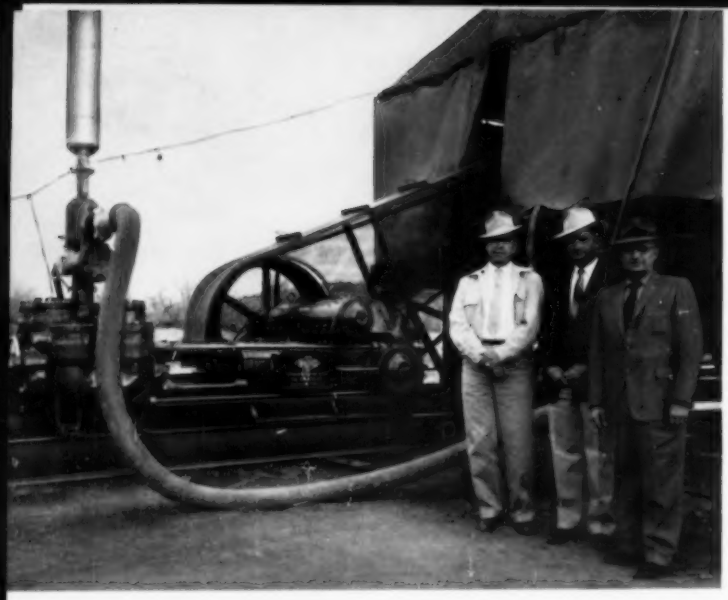

"This pump's performance was so satisfactory . . . bought a new (Wheland) HP-8000 pump for the smaller rig."

—J. W. Hastings

Here's the dependable Wheland HP-14000, still doing a fine job after 5 years in the field. Standing left to right, are Mr. J. W. Hastings, Owner; Mr. C. T. Coffman, Drilling Supt.; Mr. Joe Don Carlos, Wheland Rrepresentative.

J. W. HASTINGS
DRILLING CONTRACTOR
720-722 WICHITA NATIONAL BANK BUILDING
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April 15, 1957

Mr. Gordon P. Street, President
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Dear Mr. Street:

I purchased one of your HP-14000 pumps five years ago which has cut a tremendous amount of hole with virtually no repair expense.

This pump's performance was so satisfactory that when I began acquiring new machinery, bought a new HP-8000 pump for the smaller rig.

Both of these pumps are still in operation and doing a satisfactory job.

I operate two rigs in North Texas area. We drill contracts, interest deals and for our own account, from 2,000 - 8,500 feet.

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J. W. Hastings

FIRST PUMP'S RECORD SOLD THE SECOND!

5-YEAR RECORD

OF OUTSTANDING PERFORMANCE

"virtually no repair expense"

—J. W. Hastings

WHELAND HP-14000

7½" x 14" DUPLEX SLUSH PUMP

350 Horsepower Nominal Input at 60 RPM
Discharge pressure with 7½" liners 838 PSI
Discharge pressure with 5½" liners 1627 PSI
Dependable Operation • Lower Maintenance
Delivers more pressure per pound of pump!

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COREXIT prevents sub-surface corrosion, saves up to $1,000 a year per well

Field experience shows that the use of Humble's COREXIT in pumping wells costs so little compared to the expense of well-pulling jobs and the cost of replacing broken rods, pumps and corroded tubing, that annual savings up to $1,000 per well are not unusual.

The initial COREXIT treatment cleans up your sub-surface equipment, displacing corrosive brine and loose scale from metal surfaces. Then it builds up a tenacious and lasting protective film on these cleaned metal surfaces to prevent further corrosion and hydrogen embrittlement. The continued use of a small amount of COREXIT will maintain this tough protective film. Thus COREXIT lowers your lifting costs and improves operating efficiency by prolonging the life of your equipment and reducing the number of well-pulling jobs.

COREXIT is readily available at Humble wholesale plants throughout Texas and New Mexico.

• *For complete information on COREXIT, call your nearest Humble wholesale plant in Texas and New Mexico, or phone or write:*

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P. O. Box 2180
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Pet-Chem, Inc.
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FOR DRILLING

Power mud pumps designed for heavy-duty loads at every drilling depth:

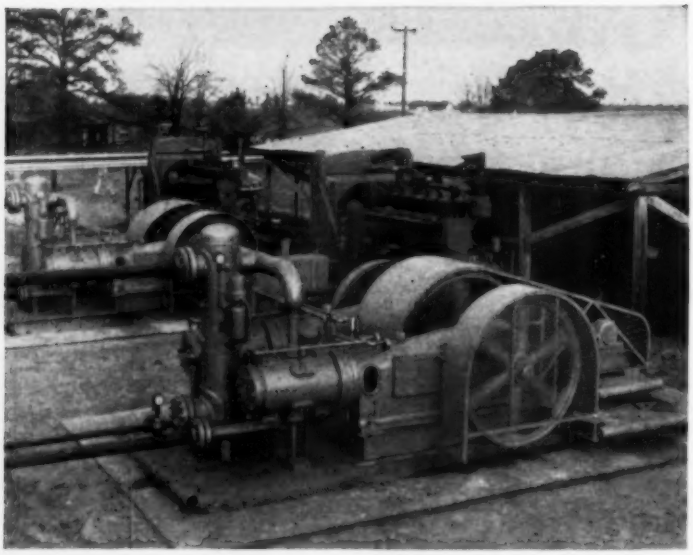
GXH 1250 hp.	GXR 1000 hp.
GXP 625 hp.	GXN 500 hp.
GXQ 350 hp.	FK-FXK 255 hp.
FZ-FXZ 185 hp.	FO-FXO 122 hp.

Quality mud pump parts.

Water-cooled compressors for air drilling and mud aeration.

Air compressors for powering rig equipment, engine starting and general service.

GX mud pumps for offshore drilling rigs. Eccentric construction keeps bearing pressures low. Counterbalanced crankshaft.



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Gas booster compressors . . . in capacities and pressures to meet service requirements.

Power pumps for gathering, transmission.

High-pressure pipeline testing compressors.

"Quadril"* . . . multiple rock drill rig equipped with remote-hydraulic controls.

"TWINDRIL"® . . . provides twin drilling power for short stretches of rocky trench.

Drill steel . . . carburized and shot-peened.

Five models of rotary portables:
RP900 RP600 RP365 RP210 RP125
*Trade-Mark

Gardner-Denver RX gas booster compressor with combination cooler keeps pressure up; engine, compressor and gas cool.

OTHER GARDNER-DENVER OIL FIELD PRODUCTS

- Duplex steam pumps.
- Pumps and compressors for seismograph rigs.
- New Gardner-Denver "Mole-Dril"* for drilling shot holes.
- Centrifugal pumps.
- Air hoists, drills, impact wrenches and other air tools.
- Air motors for such applications as remote control of pipeline valves.

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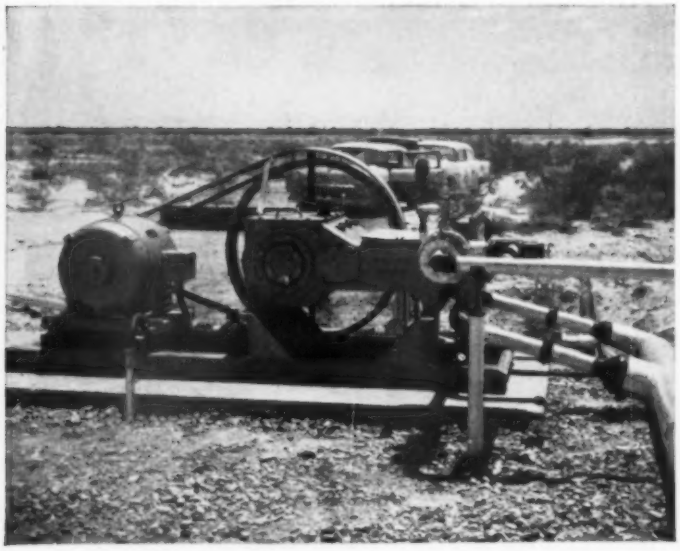
. A GREAT NAME IN THE OIL FIELDS



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The most complete line of quality power pumps for waterflood and salt water disposal:

PL-7 six-cylinder plunger—240 hp.

PA-8 triplex plunger—160 hp.

PE-5 triplex plunger—75 hp.

PG-3 triplex plunger—30 hp.

FG-FXG duplex piston—60 hp.

FF-FXF duplex piston—40 hp.

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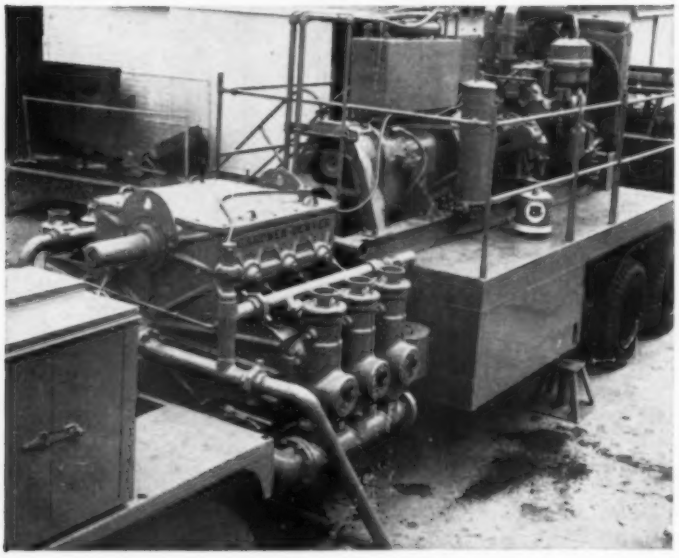
Repressuring compressors.

Air-gas lift compressors.

Gardner-Denver PG-3 has built-in reserve strength for continuous waterflooding operations . . . offers a wide range of capacities and pressures.



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High-pressure pumps for cementing, acidizing, fracturing, and work-over service:

PL-7 six-cylinder plunger pump for squeeze pressure pumping to 10,000 psi.

PA-8 triplex plunger pump for high-pressure pumping to 8000 psi.

PE-5 triplex plunger pump for high-pressure pumping to 6000 psi.

The compact design of the Gardner-Denver PL-7 triplex plunger pump makes this high-pressure well servicing pump easy to mount on truck.

Pump and compressor service specialists located throughout the oil fields.

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MOST VERSATILE NEW SERVICING

CARDWELL MODEL A-150 AND A-151

DOUBLE DRUM HOISTS

with optional spudding or rotating drive

Here are the most efficient servicing units in the lightweight class — to date! Model A-150 is powered by a rugged oil-field-type engine, and Model A-151 features PTO drive from truck engine.

Both of these versatile double-drum hoist units are rated to 5,000 feet servicing with 2½-inch tubing, but have been operated on occasion at greater depths. Both will spool 11,000 feet of ½-inch swab line. Either unit can be used for rotary drilling to 2,500 feet with 3½-inch drill pipe.

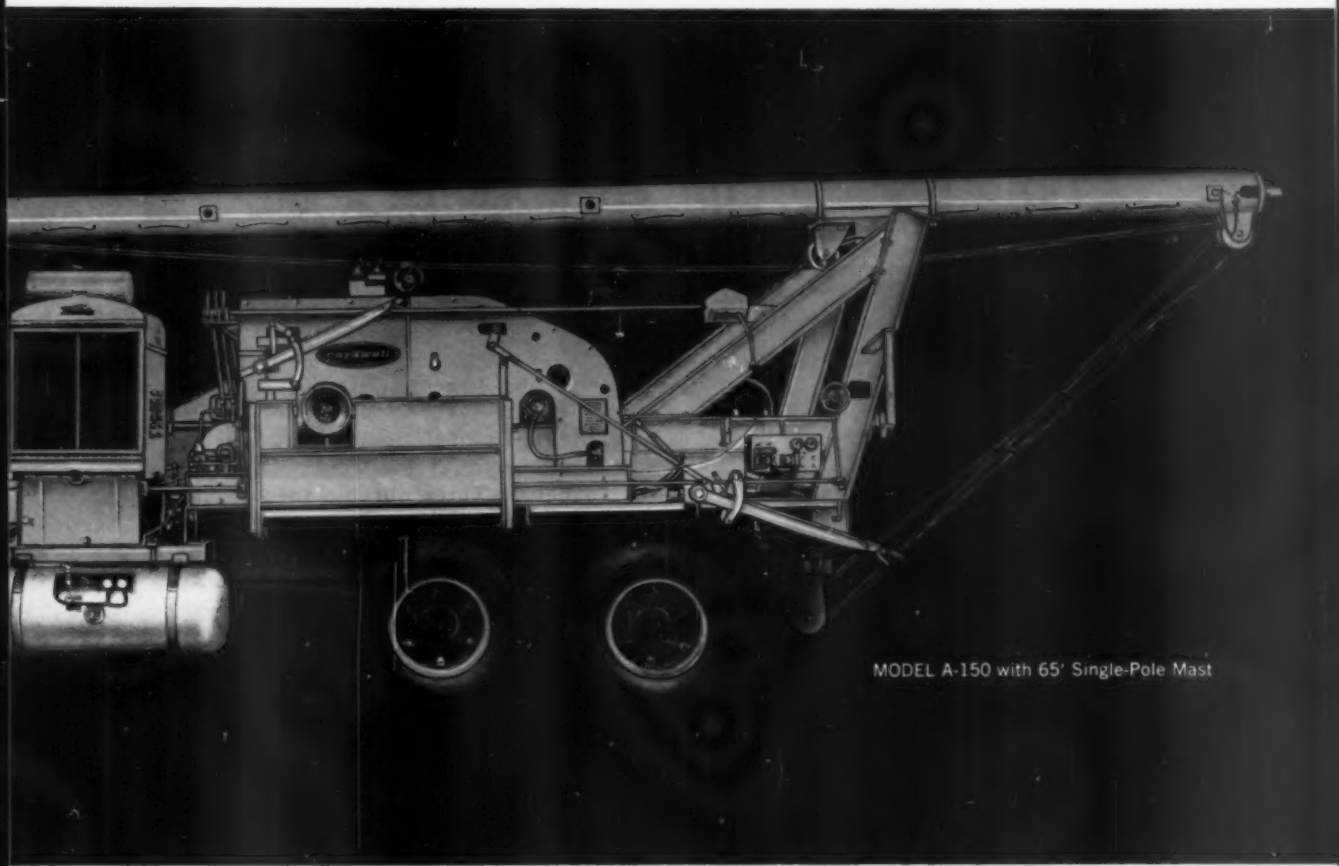
Nominal input is 120 HP, with five forward and one reverse speeds to hoisting drum, sand line drum, and rotary drive.

Increased versatility is obtained when these new Cardwell units are used with Cardwell's structural masts. Masts are equipped with outriggers to eliminate ground guy lines, and are prepared for hanging rods and standing tubing.

These new servicing units are just two of many new achievements Cardwell has planned for the industry in 1958. FOR **TOMORROW'S** EQUIPMENT... KEEP YOUR EYE ON CARDWELL — **TODAY!**

ADAPTABLE TO ANY OF THESE CARDWELL MASTS

UNITS IN THE FIELD TODAY!



MODEL A-150 with 65′ Single-Pole Mast

MODEL A-151 with
65′ Single-Pole Mast

55-foot Single-Pole Mast
55-foot Double-Pole Mast
65-foot Single-Pole Mast
65-foot Double-Pole Mast
50-foot Non-Telescoping Structural Mast
65-foot Telescoping Structural Mast

STAND-OUT FEATURES!

- Cardwell "Flex-Disc" air clutches for main and sand line drums.
- Safety-designed controls optional between skid level and ground level.
- Both main and sand line drums have two self-energized full-wrap brakes with single-point adjustment.
- Will accommodate most Cardwell single- or double-leg pipe masts and structural masts.
- Model A-150 engine driven with torque converter optional.
- Model A-151 drives from truck engine with power take off. Torque converter optional.

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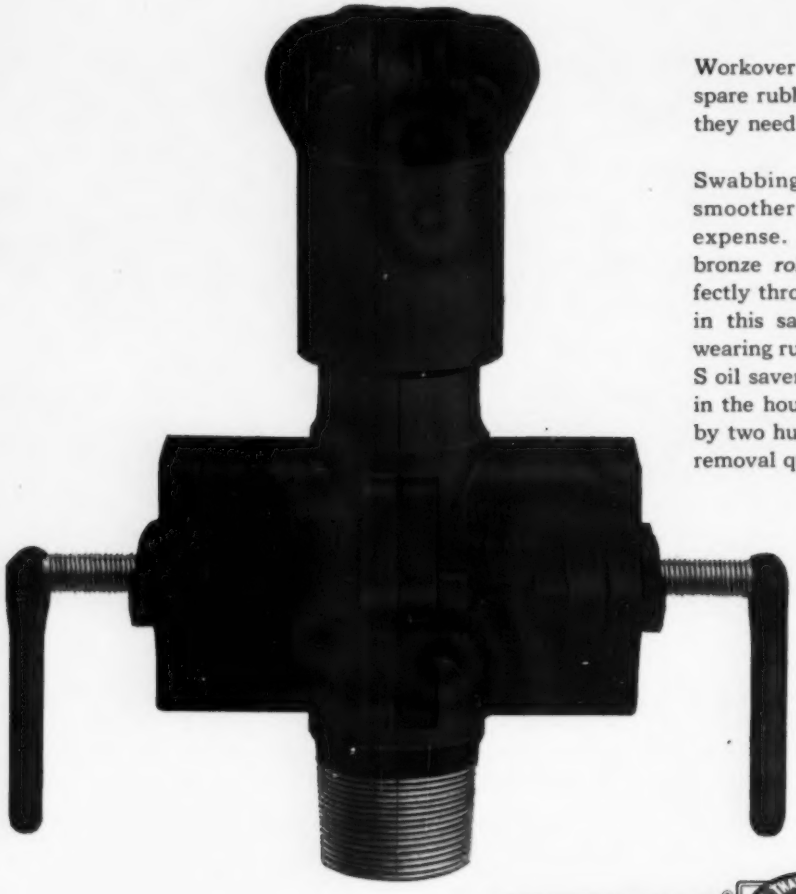
LONG TIME BETWEEN CHANGES!

When You START Using Guiberson's

Type U Wire Line Oil Saver



Workover crews tell us they keep fewer spare rubbers on the rig for this saver — they need changing so seldom.

Swabbing operations go along a lot smoother with less trouble and less expense. Three durable special alloy bronze *rollers* center the wire line perfectly through the saver. And the rubbers in this saver are the same large, long-wearing rubbers used in Guiberson's Type S oil saver — they won't extrude or stick in the housing. Split-type housing, joined by two husky bolts, makes installation or removal quick and easy.

Use the Type U singly, or in tandem leaving off the roller cap on the lower saver. When you do need them, get Guiberson replacement rubbers packed two pair to a blue and yellow box.

Get the Best — Get Guiberson.

Available in 2" or 2½" EUE 8 round double pin sizes and 3" 8V line pipe or 3" EUE 8 round double pin sizes for ⅜"-7/16", ½"-⅝" or ¾"-1" wire line.

SAFE THAN SORRY — BETTER BE — GUIBERSON

THE GUIBERSON CORPORATION

ESTABLISHED 1919
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ONE OF THE DRESSER INDUSTRIES

Sold by
Oil Field Supply Stores
Everywhere

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Why Rib-Tops are *first* in the oil fields of the world

The four engineering developments shown at the right have made Rib-Top first choice for mud pump operation with drillers around the world.

Yet Rib-Tops cost no more than ordinary belts of comparable ratings.

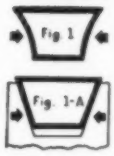
For fewer V-belt replacements and lower cost on mud pump drives, always specify Rib-Top. Both Standard and Super Rib-Top are available at your nearby oil field supply house.

Put Super Rib-Top on your toughest drives.

With 40% more horsepower capacity, Super Rib-Top easily handles drive overloads. Fewer belts and narrower sheaves solve space and weight problems.

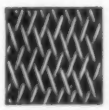
No other V-Belt has ALL these advantages

1. **Tougher, more resilient cords** are able to absorb the severe pulsations of mud pumps; easily handle peak loads.



2. **Concave Sidewalls** (U.S. Pat. 1813698) Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . far longer belt life.

3. **Stabilizing ribbed tops** (U. S. Pat. No. 2548135) are exclusive with Gates. They dampen vibration, protect top of belt from damage, keep belt running smoothly over idler-equipped mud pump drives with no side whip.



4. **Flex-Weave Cover** (U. S. Pat. 2519590) A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life . . . more power available to driven machine.

Gates® *World's Largest Maker of V-Belts.*

The Gates Rubber Company
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Gates Rib-Top Vulco Rope

DEVELOPED ESPECIALLY FOR MUD PUMP DRIVES

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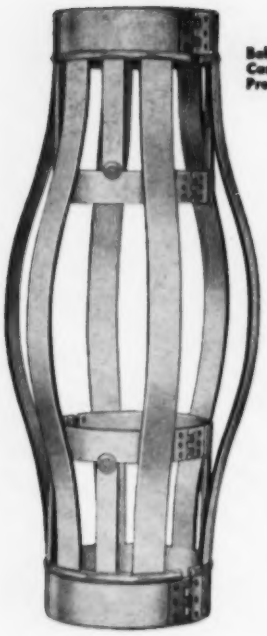


Baker Model "H-20"
Casing Centralizer
Product No. 9112

a size and type...

Model "H-30"
(3" Bowed Height)
Product No. 9114

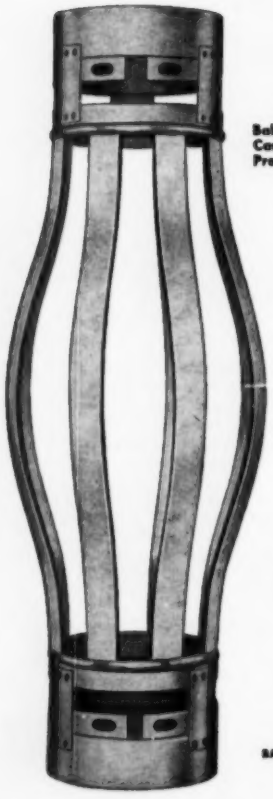
Model "H-25"
(2½" Bowed Height)
Product No. 9113

Model "H-15"
(1½" Bowed Height)
Product No. 9115

Model "H-20"
(2" Bowed Height)
Product No. 9112

"TAILORED" to your needs because Baker Casing Centralizers are made with bowed height ("effective reach") of springs from 1¼" to 5"—for a range of open hole diameters from 5⅜" to 26½"—and to run on casing sizes from 4½" to 16". It's easy to see that the *exact* size is available to fit *your* casing and provide effective centering in the greatest practical range of open hole diameters.

"tailored" to your needs...



Baker Model "G-20"
Casing Centralizer
Product No. 910-G

Model "G-30"
(3" Bowed Height)
Product No. 910-G

Model "G-12"
(1½" Bowed Height)
Product No. 910-G

Model "G-15"
(1½" Bowed Height)
Product No. 910-G

"TAILORED" to your wishes, and you can choose between the Baker Model "H" HINGE-LOK Centralizer which is closed and locked around the casing coupling or stop ring—or you may prefer the Baker Model "G" SLIP-ON Centralizer which is merely slipped over the casing and positioned with stop rings.
Ask the Baker representative about "Protective" primary cementing using Baker Casing Centralizers in combination with Baker Wall Scratchers and Baker Cementing Shoes and Collars.

for better cementing

One of the partners in
BAKER "Protective" Cementing

Baker Flexiflow Fill-Up Collars and Shoes
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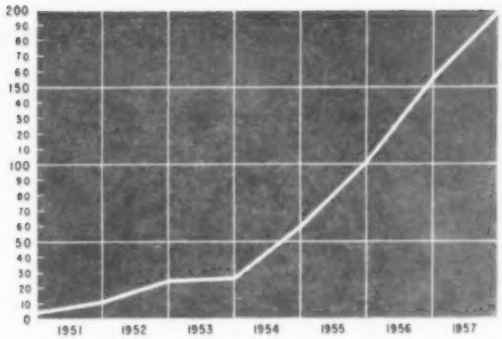
Operators drilled 199 holes 15,000 ft or below in 1957 at a cost of $148 million.... Discovered 15 fields, 45 new sands and extensions, and added 33 producing field wells



NUMBER OF 15,000-FT WELLS BY YEARS

DEEP WELLS INCREASE 28%

Ernestine Adams

THERE IS AN OLD TALE of the oil man who went to heaven and found it overcrowded. St. Peter told him they hadn't room for him.

"Are there many oil men here?" he asked.

"Oh yes," said St. Peter, "We have a great many oil men."

"And if I get some to leave, can I have a room."

"I don't see why they would but I'll agree to give you the first vacancy."

Soon after there was an exodus of oil men and the newcomer was well provided for but he didn't seem happy.

"What's the matter with you?" asked St. Peter. "I've filled my agreement and you're safely in heaven."

The oil man looked worried. "It's this way, St. Peter. I told my friends there was a strike in hell and they all beat it down there to get in on the play. The more I think about it, the more I wonder if there isn't some truth to it."

This 12th annual survey indicates that if oil men keep on drilling down, they are going to find out.

They drilled 199 wells 15,000 ft and below in 1957 alone, bringing the total to 614 wells at these depths in the United States.

Sputniks and Vanguards pierce the space above us but one lone U. S. industry has more knowledge of the earth we live on than all the political powers that be.

Their energetic investigation of three and four miles below the surface has been to some purpose. Of the 614 drilled, 291 have found oil and/or gas in producible quantities. They have been wildcats, semi-wildcats and development wells. A fair sized number[1] —9 in 1957 — are shut-in gas wells waiting for markets.

Miss Adams is Management Editor.

Increase in 1957

At the same time all drilling, including deep wells, dropped 8 percent, wells drilled 15,000 ft and below increased 28 percent during 1957.

You can draw a number of conclusions from this fact:

First — the obvious one — shallow fields have been found; there is no place in the U. S. to go but down.

Second — we have gotten into offshore gulf operations and they are on the deep side.

Third — company geologists find the best way to develop a field is to get a good "basement" well for information.

Fourth — deep wells find more oil and gas. Of 119 wildcats and semi-wildcats drilled this year, 60 found new fields, new sands, or extended fields. That is, 60 percent of wildcats 15,000 ft and below have added to reserves. This includes 3 wells shut in after discovering gas reserves of commercial size.

Deep Fields and Extensions

Pan American and Hunt discovered the deepest new field this year. A state lease offshore Terrebonne Parish in Block 39, the well went to 18,002 and was perforated at 16,828-42 ft. Initial production was 46 bbl daily condensate and 4150 Mcf gas. (See Table 5 for data on any well mentioned.)

Also in Louisiana, Howell, Holloway & Howell Petroleums, Ltd., discovered a field at 15,204-10 ft in Lafourche Parish. Initial production was 256 bbl a day of 44.1 gravity oil and 3100 Mcf gas. Here operators found 52 ft of net oil sands below 15,000 by drilling to 15,278 ft TD. Another location by HH&H at the St. John field drilled to 17,212 ft and added a dual completed well with production at 15,090-8 and 15,102-41 ft.

Sid Richardson Carbon Company and Amerada found a new sand in Abbeville field, Vermilion Parish below 15,000 ft.

Texaco extended Caillou Island field, Terrebonne Parish, to below 15,000-ft production and also drilled another well to find pay at 16,144-6 ft. Initial production for the latter was 243 bbl a day of 31.6 gravity oil and some gas. Four wells in Caillou Island field now have below 15,000-ft production.

Pure Oil shut in its discovery in Natrona County, Wyoming. Deepest in the state, its No. 1 Badwater unit tested 5500 Mcf gas. Perforations ranged from 15,216 to 16,477 ft.

British-American was operator for five more producers at Carter-Knox field, Grady and Stephens County,

[1] We have no record of whether deep gas wells shut in previous to 1957 have found markets.

TABLE 1. NUMBER OF WELLS COMPLETED 15,000 FT AND BELOW BY YEARS OF COMPLETION.

Year	No. wells by date of completion	Wild-cats	Average drilling time	Record drilling time	Average bits per well	Low bit record	Mud costs, average	Well costs, average	Average costs per ft	Total footage drilled	Ft/well average	Deepest well	Deepest producer
1938	1	1		284		195				15,004		15,004[1]	13,175[1]
1944[1a]	1	1		516		324				16,246		16,246[1a]	
1945	4	4	490		222					63,480	15,870	16,655[2]	13,175
1946	1	1		349		184				15,452		16,655	13,175
1947	8	8	267	121	181	73	$24,000	$570,000	$35.87	127,128	15,891	17,823[3]	13,904[4]
1948	7	6	328	113	303	99	28,000	551,000	34.34	112,329	16,047	17,823	14,255[5]
1949	11	8	222	95	199	120	64,000	534,000	32.52	180,631	16,421	20,521[6]	15,530[7]
1950	5	2	235	150	181	106	63,000	577,000	36.72	78,565	15,713	20,521	15,530
1951	12	5	178	96	116	69	54,000	527,000	33.56	189,864	15,822	20,521	15,530
1952	25	17	212	83	138	44	66,000	549,000	34.77	396,850	15,874	20,521	16,102[8]
1953	26	14	213	70	159	48	75,000	729,000	44.79	419,053	16,117	21,482[9]	17,895[10]
1954	59	30	182	71	117	40	92,000	651,000	40.87	939,808	15,929	21,482	17,895
1955	101	64	147	37	87	44	116,000	649,000	40.09	1,635,101	16,031	22,559[11]	17,895
1956	155	77	150	36	89	31	122,000	683,000	42.18	2,510,050	15,988	22,559	20,745[11]
1957	199	119	158	48	89	30	121,000	743,000	46.25	3,196,673	16,064	22,559	20,745
Overall	614	356	169	36	105	30	$107,000	$680,000	$42.25	9,879,988	16,091	22,559	20,754

WELLS HOLDING RECORDS:

1. Continental KCL No. A-2, Kern County Calif.
1a. Standard of California KCL 20-13 drilled in 1944 to TD and abandoned in 1945. Inserted here to show record depth.
2. Phillips Schoeps No. 3, Brazos County, Texas.
3. Superior Weller No. 51-11, Caddo County, Okla.
4. Texaco Lafourche Basin Levee No. 1, Jefferson Parish, Louisiana.
5. Shell J. A. Smith "A" No. 1, Iberia Parish, La.
6. Superior Pacific Creek Union No. 1, Sublette County, Wyoming.
7. Standard of California Mushrush No. 5, Kern County, Calif.
8. Pure Oil W. Poison Spider No. 3, Natrona County, Wyo. (Gas).
9. Ohio Oil KCL No. 72-4, Kern County, Calif.
10. Richfield Oil Coles Levee "A" 67-29, Kern County, Calif.
11. Richardson & Bass 1-L SL 2414, Plaquemines Parish, La. Drilled to TD in 1955. Completed in 1956.

Oklahoma. A new producing depth in the field at 16,630 ft was reached by B-A, Ohio, and Gulf No. 1 S. Krieger.

Deepest extension this year was Richardson & Bass, Humble, R. F. Price No. 1 State Lease 2345 in Lake Washington. Deepened to 21,186 ft on a sidetrack, a new sand was discovered at 19,151-74 ft. IP was 795 bbl a day of 39.7 gravity oil and 1735 Mcf gas.

J. W. Mecom-Freeport extended the Lake Washington field, Plaquemines Parish, with production from 15,180,-200 ft.

Lake Washington field is the one that now holds the world depth record — 22,570 ft — and the world production record — 21,465 ft. The well with both records is Richardson & Bass, Mecom-Freeport, Humble State Lease 2414. It was reworked this year.

Shell added two producers below 16,000 ft and one below 15,000 ft at Weeks Island field, Iberia and St. Mary Parish. A fourth extension in this largest deep field to date found a new sand in the 12,982-92 ft zone.

Superior extended Four Isle field, Terrebonne Parish, Louisiana, 1400 ft deeper. Initial production of its Terrebonne Land & Development No. 1 was 104 bbl a day condensate and 2601 Mcf gas.

Table 3 now shows 28 fields producing below 15,000 ft, with 84 wells, 26 being added in 1957. Of the 28 fields 21 are in Louisiana.

New Shallow Fields

Besides the three deep fields, the 119 wildcats and semi-wildcats in 1957 discovered 12 new fields above 15,000-ft depth. Three opened new fields below 14,000 ft: Magnolia at Lake Arthur, British American at Ramos, and Wm. T. Burton at Lake Patourde. J. W. Mecom made a discovery below 13,000 ft at Bay St. Elaine.

Below 12,000 ft new fields were found by Hassie Hunt Trust at Wildcat Bayou, by Shell offshore of Terrebonne Parish, and by Buffalo Oil at North Leroy. All these are in Louisiana.

Shallower fields were discovered by deep wells: By Standard of California in Ventura, California; by Phillips Petroleum in Rio Blanco, Colorado; by Humble in Harris County, Texas; by Union of California in Terrebonne, and by Gulf in Plaquemines Parish, Louisiana.

Of new sands and extensions to fields above 15,000-ft pay zones 21 were added by deep holes in Louisiana, two by those in Texas and one by Continental's big gasser in Lea County, New Mexico.

The 1957 deep wells found 15 new fields, and made 45 extensions or new sand discoveries in old fields. For new fields, 1 out of 8 "wildcats" drilled were successful. However, a number of the

TABLE 2. LOCATION AND AVERAGES OF WELLS DRILLED 15,000 FT AND BELOW.

State	Number wells 1957	Total 15,000 ft holes	Completed as producers	Drilling time average days	Low drilling time record	Average bits per well	Low bit record	Deepest hole	Mud costs, average	Well cost average
Alabama	1	3	0	225		186		15,729	$55,000	$490,000
California	6	36	10	191	58	160	56	21,482	90,000	653,000
Colorado	1	2	2	304	167	242	161	17,033		658,000
Florida	0	1	0		485		144	15,155		
Louisiana	154	436	226	133	48	76	30	22,570	108,000	661,000
Mississippi	3	9	2	268	105	153	76	20,450	84,000	528,000
New Mexico	4	11	6	335	222	234	172	16,842	114,000	905,000
Oklahoma	9	21	12	351	217	236	154	20,446	106,000	821,000
Texas	20	87	30	234	90	156	40	21,687	118,000	726,000
Wyoming	1	8	3	385	318	252	199	20,521	74,000	904,000
TOTALS	199	614	291	169	48	105	30	22,570	$107,000	680,000

TABLE 3. FIELDS WITH PRODUCTION 15,000 FT AND BELOW.

Field	County or Parish	State	No. wells that produced below 15,000 ft	Deepest production ft
North Coles Levee	Kern	California	1	17,895
Wasco	Kern	California	1	15,530
Rayne Lane Well	Acadia	Louisiana	1	15,270
Deep Lake	Cameron	Louisiana	1	15,410
Avery Island	Iberia	Louisiana	2	15,496
Weeks Island	Iberia & St. Mary	Louisiana	28	17,745
Queen Bess Island	Jefferson	Louisiana	3	16,149
Lake Arthur	Jefferson Davis	Louisiana	2	15,784
Bay de Chene	Lafourche & Jefferson	Louisiana	2	15,235
Timbalier Bay	Lafourche	Louisiana	1	15,730
St. John	Lafourche	Louisiana	2	15,210
Lake Washington	Plaquemines	Louisiana	5	20,745
Venice	Plaquemines	Louisiana	1	15,860
Cade	St. Martin	Louisiana	1	15,085
Cote Blanche Island	St. Mary	Louisiana	4	16,415
Bayou Rambio	Terrebonne	Louisiana	2	15,034
Caillon Island	Terrebonne	Louisiana	4	16,116
Block 39 SS	Terrebonne (offshore)	Louisiana	1	16,842
Dog Lake	Terrebonne	Louisiana	2	15,879
Four Isle	Terrebonne	Louisiana	2	16,908
Lake Pelto	Terrebonne	Louisiana	2	16,084
Lapeyrouse	Terrebonne	Louisiana	1	15,035
Abbeville	Vermilion	Louisiana	1	15,012
San Simon	Lea	New Mexico	1	15,025
Carter-Knox	Grady & Stephens	Oklahoma	6	16,630
Puckett-Ellenburger	Pecos	Texas	3	15,324
West Poison Spider	Natrona	Wyoming	2	16,102
Badwater	Natrona	Wyoming	1	16,477

119 wildcats were deep tests —not rank wildcats.

New State Depth Records

Three states had new depths probed in 1957. Phillips Petroleum No. 1 Mannell in Rio Blanco County, pushed Colorado's record depth 2000 ft more than it was, to 17,033 ft. It discovered a shallow gas field.

Magnolia drilled to 20,446 in Caddo County, Oklahoma, displacing the former 18,158-ft record. It was a dry hole.

Texas got a new record depth of 21,687 ft. Pan American Petroleum drilled to this depth in Pecos County but did not find commercial production.

Drilling Time

Drilling time for deep wells increased in 1957 to 153. All-time low was in 1955 (Table 1) when average was 147 days to drill a deep well.

Record drilling time also went up. Last year it reached a low of 36 days for a deep well. This year the record is 51 days, made by two wells; F. A. Callery, Inc. No. 1 Provost, Lafayette Parish (Circle Drilling Company, contractor), and by Gulf No. 1 Louisiana State "PP", Plaquemines Parish, (Producers Drilling Company, Inc., contractor).

Louisiana continues to hold the lowest average drilling time of any state, with California second.

Drilling Bits

Bit record in 1957 dropped to 30 bits, an achievement of Caroline Hunt Sands No. 1 State Lease 3136, Atchafalya Bay, Louisiana. Penrod Drilling Company was contractor.

Number of bits used has declined with bit improvement. This should cut down drilling time and might have done so except for several wells completed in 1957 that took well over a year to drill. Another trend that keeps both bits and drilling higher is the practice of sidetracking. (See below.)

Texaco Drilled 106

For the first time one company went over the mark of 100 deep wells. The Texas Company has been operator for 106 wells 15,000 ft or below.

From Table 6, where all operators are listed alphabetically, we can select the operators of the largest number of deep wells: The Texas Company 106, Shell Oil 51, Humble 41, Pan American 36, Phillips 32, Magnolia 31, Gulf 30, and Superior 29.

Individual operators who have contributed to deep exploration are Sid Richardson, H. L. Hunt, and John W. Mecom. H. L. Hunt's companies have drilled 25 deep wells. Sid Richardson has had interests in 27 as operator. John W. Mecom has been operator for 25 deep wells.

Probably the most interesting factor regarding the operators is how many companies get in the act. So far 81 companies or individuals have been operators of these super-deep wells. This doesn't begin to tell how many are interested financially because it isn't uncommon for a half dozen to contribute to one of these million-dollar projects. This spreads the risk.

Big Rig Contractors

Drilling contractors have certainly kept up with the deep trend. There are now 83 contractors who have successfully drilled a 15,000-ft hole.

Last year 28 contractors were added to the list of those equipped and manned for deep operations. Table 7 gives the names and addresses of all 83 contractors that have deep drilling experience.

Costs Go Up

The oil industry spent nearly $150 million in 1957 for 199 wells. This is the highest average well cost so far recorded (Table 1); only other year when cost per well went over $700,000 was in 1953. Some of the raise is due to sidetrack operations. Costs are given for the entire operation although there may be one original hole and two sidetracks.

There is always a wide range of costs for deep wells, often in the same area. The last three years, however, have produced enough deep wells to arrive at a reasonable average.

This is not true of individual states (Table 2) where six states have less than 12 deep wells each.

Average cost per foot in 1957 went to $46.25. This carries the overall average to $42.25 per ft for 614 wells

Continued on Page B-29

THANKS TO

DEEP WELL OPERATORS

and

RINEHART REPORTS

this survey is possible. We have had virtually total cooperation in gathering the information collected here. Our sincere appreciation goes to these oil companies that provide essential data, particularly cost figures. Tables are reworked when data are added on wells drilled in former years.

TABLE 4. PRODUCING DEPTHS OF DEEP WELLS.

Producing depth, ft	Producers	Producing depth, ft	Producers
2- 3,000	2	12-13,000	32
4- 5,000	3	13-14,000	49
5- 6,000	2	14-15,000	53
6- 7,000	4	15-16,000	64
7- 8,000	5	16-17,000	20
8- 9,000	7	17-18,000	10
9-10,000	7	19-20,000	1
10-11,000	9	20-21,000	1
11-12,000	21		
TOTAL PRODUCERS	291		

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW

1. TD, ft. 2. Prod. depth	Company Well	Drilled by	Field/Area County/Parish	Completed Spudded	Mud program	Perforations in prod. zones	Initial prod., gravity, coke, tubing pressure	Remarks
			ALABAMA					
15,350 D & A	Humble #1 Champ. & Klepac	Trans-Tex. Drlg. Co.	Jackson Fault Clarke	7-28-57 12- 4-56	Lime		None	WC. (wildcat) ST 14,722.
15,022 11,540	Standard Calif. Borchard 1	Rocky Mt. Drlg. Co.	W. Montalvo Ventura	3-13-57 11- 9-56		9970-11,540 Sespe	40 B 25.0 Pumper TP50 CP 1000	WC. Disc. new field. Overall thickness formation 1570'.
15,121	Standard Calif. Sespe Ranch 12	Loffland Bros.	Section 26 Ventura	11- 6-57 8-20-57		13,835-937 Spalding	200 B 30.6° 25 mcf 21/64" TP 450-850	FW.
15,298 D & A	Humble M. A. Tippetts Est. 1	Coastal Drlg Co.	Rumsey Hills Yolo	12- 8-57 10-15-56	Shale ban		None	WC.
17,422 12,720	Standard Calif. McGrath 4-1212	Bell & Burden	W. Montalvo Ventura	5-26-57 12-15-56		12,385-720 Colonia	44 B 21.4° 171 mcf 21/64" TP 500 CP 1600	FW. Overall thickness sand-335'.
17,485 D & A	Texaco Lawton 1	Rocky Mt. Drlg Co.	Fairview Canyon Ventura	1-13-57 8-15-56			None	WC.
			COLORADO					
17,033 4,063	Phillips Mannell 1	Phillips Rig 25	Rio Blanco	7-16-57 11-29-55	Low solids Hi Vis Driscose	4,043-63 Ft. Union Sd.	7800 mcf 2" open P 1388	WC. Disc. new gas field.
			LOUISIANA					
15,000 14,454	Gulf Oil SL* "PP" #1	Producers Drlg. Co.	Pomme D'Or Plaquemines	12-29-57 10-25-57	17.8# at TD	14,436-54 Miocene	1586 mcf (dry) 19/64" P 2850	WC. Disc. new field.
15,000 D & A	Bell Isle Well 37	Sun Oil Barge 1	Belle Isle St. Mary	12- 4-57 8- 5-57	Lime-treated oil emul. 16.2#		None	Field well temp. abd. offshore.
15,00 D & A	Sun Oil Leger 1	H. E. T. Co. Rig 1	S E Rayne Arcadia	1-25-57 9-26-56	Lime-treated oil emul. 17.8#		None	WC.
15,000 D & A	Magnolia SL 6810CS 044	Magnolia Rig	Eugene Is. B. 110 St. Mary	2- 9-57 11- 3-56	Saturated salt surfactant		None	WC. Offshore.
15,000 shut-in	Humble Gilmore 5	Hawkins-Wilkins	Florence Vermilion	7- 1-57 2-24-57	Lime-treated CMC	Miocene formation	Gas	WC. Completed as potential gas well.
15,002	Union Calif. S L 2826 & LLE 1-D	Dixie Drlg Co.	Caillou Is. Terrebonne	6-19-57	Lime-base 17.0#		130 B 33.9° 119 mcf 5/64" P 2000	WC. Original completion 12-6-56. Disc. new field.
15,006 D & A	Magnolia A. West Heirs 8	Magnolia Rig 21	Holly Beach Cameron	1-18-57 8-17-56	Lime-base		None	FW.
15,006 12,782	Shell OCS-0587 No. 1	Kerr-McGee	Ship Shoal 138 Terrebonne	9-12-57 6- 1-57		12,768-82	168 B 61.4° 2500 mcf 1/4" P 2050	WC. Disc. new field offshore.
15,010 D & A	Caroline Hunt Sands S L 3136 #1	Penrod Drlg. Co.	Atchafalya St. Mary	11-18-57 9-19-57			None	WC.
15,014 D & A	Calif. Co. LL & E 1	Norton Drlg. Co.	Lafourche	3- 8-57 7-16-56	Red-base to 10,973; lime-base TD		None	WC.
15,014 11,948	Union Calif. LL & E1 S L 2826		Timbalier Terrebonne			11,834-44 11,938-48	325 B 34.2° 8 160 B 35° 1/32"	WC. Dual comp. Disc. new field.
15,018 13,108	Monterey Bowie Lbr. 3	C. G. Glasscock Drlg.	L. Boeuf Lafourche	11-19-57 5-21-57	Lime-base oil emul.	13,101-8	154 B 33.2° 19/64" P 1120	WC. below 13,090. Disc. new sand.
15,020 D & A	Warren Pet. Lafourche Rlty 2	Loffland Bros.	20-20S-23E Lafourche	6-11-57			None	WC.
15,025 D & A	Seaboard Lacassane 1	C. B. Webster Drlg. Co.	W. Thornwell Cameron	10-10-57 6-19-57	Lime-base 17.9#		None	WC.
15,025 12,321	Texaco So. La Canal & & Nav. 5		Leeville Lafourche	10-13-57		12,315-21	130 B 36.7° 1/8" P 1050	FW.
15,025 D & A	Alcoa H. Melancon 4		Sec. 28 St. Mary	7- 5-57 4-21-57			None	WC.
15,030 D & A	Miss. River Fuel S L 2828-1		Lafourche	11-17-57			None	WC.
15,031 D & A	Am. Petrof. Peterson 1	C. G. Glasscock	St. Mary	12- 6-57 7- 1-57	Lime-base oil emul. below 8000'		None	WC.
15,042 D & A	Mecom-Freeport SL 2155		L. Washington Plaquemines	6-20-57			None	FW.
15,045 13,910	Texaco SL 340 No. 33		Cote Blanche Is. St. Mary	4-17-57 1-4 -57		13,690-703 13,884-910	231 B 30.1°+ 232 B 28.6° 5/64" P 2100	FW. Dual Comp.
15,072 P & A	Gulf E-8 OCS-0499	Dixilyn Drlg. Co.	Block 154 Terrebonne	4-24-57 1-12-57			None	WC. Offshore.
15,098 14,955	Superior-Rockefeller SL 2039 No. 7	Superior Rig	Constance Baym Cameron	6-24-57 3-6 -57	final 13.1# 3.7cc water loss	14,939-55 Miocene	127 B 50.3° 2054 mcf 18/64" P 1500	FW.
15,100 14,638	Texaco L. Barre 26 No. 2		Lake Barre Terrebonne	11- 2-57		14,626-38	173 B 43.4° 1853 mcf 1/8" P 5300	FW.
15,100 12,902	Humble La Furs F-2	Humble Rig 26	Pecan Isl. Vermilion	5-13-57 12- 8-56	low solids CMC	to 12,902 Opere. 8	54 B 49.4° 3446 mcf 16/64" P 4400	WC. Disc. new sand.
15,101 14,616	Superior-Rockefeller SL 2039 No. 6	Superior Rig	Constance Bayou Cameron	2-28-57 11- 4-56	final 13.1# 2.2cc wat. loss	14,606-16 14,220-30 Miocene	224 B 46.2°+125 B 45.6° 6200+ 6050 mcf. 22/64" P 2491	FW. Extended field. Dual comp. gas well.

Abbreviations: ST—Sidetrack SL—State Lease OCS—Outer Continental Shelf WC—Wildcat

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft. 2. Prod. depth	Company Well	Drilled by	Field/Area County/Parish	Completed Spudded	Mud program	Perforations in prod. zones	Initial prod., gravity, coke, tubing pressure	Remarks
			LOUISIANA — (Continued)					
15,125 14,852	British-Am. Intere. Shipyard 1	Loffland Bros.	Ramos St. Mary	9-25-57 2-18-57	lime-base oil emul.	14,672-852 Miocene	55 B 49.5° 1700 mcf $\frac{6}{64}$" P 9500	WC. Disc. new field. Blowout April 7-19, at 13,257'. Burned rig.
15,125 D & A	Mecom SL 2028 No. 5	Company rig	L. Washington Plaquemines	11-23-57 7-22-57			None	FW.
15,133 13,514	Mecom-Freeport E. Cockrell 80		L. Washington Plaquemines	12- 3-57		13,494-514	247 B 27.5° 183 cmf $\frac{13}{64}$" P 2200	FW.
15,160 D & A	Texaco SL 340 No. 23		Rabbit Island Iberia	3-16-57 11- 5-56			None	FW.
15,188 D & A	Humble Delta Sec. 8	Humble Rig 39	Bully Camp Lafourche	4-14-57 11-29-56	Low solids CMC		None	WC.
15,193 D & A	Superior Harry Bourg 6	Superior Rig	Bayou Rambio Terrebonne	6-16-57 4- 1-57	final 14.5# 1.3cc water loss		None	FW.
15,200 D & A	Texaco SL 2986 No. 3		Caillou Isl. Terrebonne	12- 1-57 8-21-57			None	WC. Offshore.
15,203 14,655	Texaco SL 35		Cote Blanche Isl. St. Mary	12-24-57 8-12-57		14,623-55	216 B 33.3° $\frac{5}{64}$" P 2400	FW. Offshore.
15,214 P & A	Pan Am. SL 751 No. C-1		Blk. 39 Lafourche	3-10-57 8-24-56			None	WC. Offshore.
15,214 D & A	Monterey SL 2443	Harry L. Edwards	Cameron	4-27-57 11-27-56	Lime-base oil emul.		None	WC.
15,218 13,550	Mecom-Freeport E. Cockrell 65	Company rig	L. Washington Plaquemines	3- 1-57 9-11-56	Lime & oil emul. 16.2# max.	13,540-50 13,380-92	453 B 27.3°-226 B 32° $\frac{19}{64}$"-$\frac{13}{64}$" P 2200-1100	FW. Dual. comp.
15,232 oil	Texaco SL 1200 Unit 32 No. 1		Bay St. Elaine Terrebonne	1- 2-57			Oil	FW.
15,250 J & A	Tex Pac C & O Cont. Ld & Fur 1	Rowan Drlg. Co.	Copasaw Terrebonne	11-27-57 9-11-57	Gel chemical & low-lime mud		None	WC.
15,278 15,210	H. H. & H. Petr. J. B. Levert 1	Howell & Howell	St. John Lafourche	4- 5-57 11-24-56	Lime-base oil emul. 15.3#	15,204-10 Camerina	256 B 44.1 ° 3100 mcf $\frac{1}{4}$" P 2600	WC. Disc. St. John field.
15,286 14,294	Humble LL & E R-6	Humble Rig 29	Bayou Penchant Terrebonne	12- 1-57 8-20-57	Lime CMC	to 14,294	216 B 39.1° 1992 mcf $\frac{17}{64}$" P 2050	FW. Drilling time only 60 days. Disc. new sand.
15,300 D & A	J. Ray McDermott Cont. Ld. & Fur 1	Offshore Drlg. Co.	Bayou Penchant Terrebonne	10-17-57 5-19-57			None	WC. TD in second ST hole.
15,300 D & A	Humble SL 2904 Wks Bay 1	Thirteen Drlg. Co.	Weeks Bay Iberia	5- 6-57 10-12-56	Low solids CMC		None	WC. Also ST.
15,336 15,200	Mecom Freeport LL & E 3	Company Rig	L. Washington Plaquemines	6-24-57 3- 3-57	Lime & oil emul.	15,180-200 Miocene	269 B 44.6° 2455 mcf $\frac{15}{64}$" P 4200	FW. Extended field.
15,342 D & A	Texaco SL 3005 No. 1		Leeville Lafourche	11-26-57			None	FW.
15,342 D & A	Calif. Co. Miami Corp. 1	Richardson & Bass	Iberia	6- 2-57 2- 2-57	Red to 13,035 gyp to TD		None	WC.
15,361 JI & A	Chacahoula Harang Farms 1	Howell & Howell	Oakley Assumption	9-14-57 6- 8-57			None	WC.
15,436 12,688	Union O & G of La. E. Roach 3	Webster Drlg. Co.	Lake Arthur Jeff Davis	9-21-57 4-30-57	Native to 9500 Lime-base oil emul. to TD	12,558-688 Lower Camerina	116 B 43.1° 5600 mcf $\frac{11}{64}$" P 6200	FW. Disc. new sand.
15,441 15,406	Shell Provost St 1		Weeks Isl. Iberia	12- 5-57			15 B 35.9° 156 mcf $\frac{1}{8}$" P 100	FW. Deepened from 15,220'.
15,450 Shut-in	Humble-Gulf SL 2869 A-1	Kerr-McGee	W. Delta Bl. 24 Plaquemines	6-17-57	Low solids CMC	Not perf.	67 B 54.2° 1643 mcf $\frac{1}{8}$" P 4420	WC. Comp. as potential gas well.
15,461 15,305	Union O & G E. Roach 2	Gordon Drlg. Co.	Lake Arthur Jeff Davis	1- 4-57 9-17-56	Native to 9509 Lime-base oil emul. TD	15,224-305 L. Oligocene	190 B 39.5° 6375 mcf $\frac{11}{64}$" Closed in $1\frac{1}{4}$" TP 11,450#	FW. Disc. new sand. Open hole completion.
15,500 15,226	Texaco SL 2070 St. Joseph 1-2	Wheless Drlg. Co.	Bay de Cheme Jefferson	2-11-57		15,214-26 Miocene	272 B 39° 1327 mcf $\frac{3}{64}$" TP 6450	FW.
15,500 13,129	Texaco Unit 3 No. 12		Lake Pelto Terrebonne	11- 4-57		13,115-29	175 B 25.1° $\frac{1}{8}$" P 1100	FW.
15,500 11,052	Sunray Mid-Con. H. Foreman	Falcon Seaboard	Ridge Lafayette	7-20-57 2-24-57	Native to 8500 Lime-base TD	11,038-52 Marginulina No. 1 sand	27 B 45.5° 2200 mcf $\frac{11}{64}$" P 5600	FW. Extended field.
15,505 D & A	Pan Am. SL 3007 No. 1		Bastian Bay Plaquemines	12- 5-57 7-22-57			None	FW.
15,505 13,536	Mecom SL 2995 LL & E Unit 3-1	Company rig	Bay St. Elaine Terrebonne	10-26-57 4-14-57	Lime & oil emul.	13,526-36 13,414-30 Miocene	346 B 30.2° & 341 B 31.4° $\frac{5}{64}$" & $\frac{15}{64}$" P 2800 & 2700	WC. Disc. new field.
15,523 D & A	Texaco Madison Rlty B-5		Lafitte 18 Jefferson	6- 7-57			None	WC.
15,526 13,978	Placid LL & E B-3		Lapeyrouse Terrebonne	12- 5-56 6-20-56	15.2# pH13 oil 10%	13,943-78 Miocene	Oil 51.1° 1500 mcf $\frac{5}{64}$" P 4850	WC. In depth. comp. in oil field.
15,532 12,128	Pan Am, Austral, Hen- derson-Petitjean No. 1		So. Thornwell Jeff Davis	5-26-57 12- 1-56		12,120-28	54 B 54.5° 2733 mcf $\frac{11}{64}$" P 7100	FW. New pay and $1\frac{1}{2}$ mile ext. Shut in gas well.

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft. 2. Prod. depth	Company Well	Drilled by	Field/Area County/Parish	Completed Spudded	Mud program	Perforations in prod. zones	Initial prod.; gravity, coke, tubing pressure	Remarks
			LOUISIANA — (Continued)					
15,556	Hassie Hunt SL 2785-1 M. S. Nelson	Penrod Drlg. Co.	Wildcat Bayou Terrebonne	5–23–57 12–15–56		12,936–44 Miocene	120 B 56° 1400 mcf 19/64" P 4350	WC. Disc. new field.
15,561 D & A	Columbian Carbon L. C. Desormeaux 1	Clegg & Hunt	Acadia	1–20–57 6–16–56	Lime-base 17.8# 65 sec. visc.			WC. Oil at 9738'. Started making 85% salt water.
15,570 D & A	Lone Star Pro. Gulf States 3	Circle Drlg. Co.	Raceland Lafourche	8–10–57				FW.
15,601 P & A	Conoco A 1 Block 102	Reading & Bates Offsh.	Offshore Vermilion	6–21–57 4– 1–57	Redlime oil emul.17.7# 80 visc. wtr. loss		None	WC.
15,604 13,821	Tidewater A Gilmore A-1	Rowan Drlg. Co.	Bastian Bay Plaquemines	8–30–57 3– 9–57	Lime-base oil emul. 15,191' Driscone TD	13,792–821 Miocene	206 B 34° 720 mcf 5/64" P 3990	Semi WC. Extended field.
15,614 15,588	Sun Oil SL 2620 No. 3	Brewster-Bartle	Lake Pelto Terrebonne	9– 8–57 8–29–56	Lime-base oil emul. w/calcium chloride 18.4#	15,584–8 R-sand	358 B 32.7° 420 mcf 5/64" P 4250	FW. Ext. field. 2 ST's & stuck 2 D/P jobs.
15,625 11,756	Sunray Mid-Con. Delma Hanks	Falcon-Seaboard	Ridge Lafayette	10–23–57 4–19–56	Native 8500' Lime-base TD	11,748–56 Upper Camerina	38 B 47° 2000 mcf 12/64" P 7550	FW. Ext. field.
15,637 D & A	Union Calif. Lutcher Moore 1	Falcon-Seaboard	L. Bridge Terrebonne	10–19–57	Lime-base at 12,000		None	WC.
15,650 13,794	Pan Am SL 3011 No. 1		Bastian Bay Plaquemines	9–13–57 4– 5–57		13,780–94	508 B 33.6° 12/64" P 1900	FW.
15,660 15,641	Shell J. A. Smith B-1	Shell rig	Weeks Isl. Iberia	4–10–57		15,630–41 V2 sand	308 B 29.7° 612 mcf 12/64' P 1500	FW. Deepened in 13 days from 15,340' well in T sand. comp. 12-20-51.
15,661 D & A	Placid-Pan Am SL 2857 No. 3	Penrod Drlg. Co.	Caillou Isl. Terrebonne	6–11–57 3–25–57	12# pH 13 oil 10%		None	FW. Directional hole.
15,664 D & A	Texco SL 200 Unit 35-1		Bay St. Elaine Terrebonne	3–28–57			None	FW.
15,679 D & A	Tidewater J. A. Heinen No. 1	Falcon-Seaboard	West Rayne Acadia	7–23–57 1– 4–57	Oil-base lime mud		None	Semi WC.
15,680 13,200	Olin Gas Trans. Grandison 6	DOC Drlg. Co.	Coffee Bay 14 Lafourche	6–25–57 2–25–57			161 B 55° 5100 mcf 1/8" P 3650	WC. Ext. field.
15,734 D & A	Magnolia Herb. Helms 1 & 1X	Magnolia Rig 10	Cameron	2– 4–57 2–10–56	Surfactant		None	WC.
15,752 D & A	Gulf et al LL&E St. Unit 1	Rowan Drlg. Co.	Bay de Chene Jefferson	11–16–57 7– 8–57	17# at TD		None	WC.
15,764 D & A	Warren Pet. School Ld No. 1	Falcon-Seaboard	Ridge Lafayette	2–11–57 6–17–56			None	FW.
15,779 12,053	Union Calif. LL&E 3-1	Gracey Hellums	Lake Hatch 9 Terrebonne	4– 5–57 10–28–56	Lime-base 18.4# max.	12,035–53	260 B 39° 3250 mcf 1/8" P 7900	FW. Extended field.
15,787 D & A	F. A. Callery L. G. Provost 1	Circle Drlg. Co.	Scott Lafayette	6–17–57 2–15–57			None	FW.
15,790 14,612	Tidewater Buras Levee 91	Rowan Drlg. Co.	Venice 98 Plaquemines	2– 1–57 10–21–56	Lime-treated oil emul.	14,602–12 Mid. Miocene	263 B 33.6° 334 mcf 18/64" P 1675	WC.
15,800 TA	Olin Gas Trans. SL 2956 No. 1	Blackie Drlg. Co.	Lafourche	2–13–57 7–28–56			None	WC.
15,806 D & A	Gulf SL 1772 No. 48		Timbalier Lafourche					FW.
15,820 D & A	Warren C. J. Mouton 1		Lafayette	1–12–57		None		WC.
15,844 14,651	Gulf SL 1772 No. 41	Rowan Drlg. Co.	Timbalier Jefferson	6–11–57 1 –4–57	17.5# at TD	14,634–51 Miocene	159 B 51.6° 1540 mcf 12/64" P 2600	FW.
15,879	Texaco Dog Lake Unit 2 No. 2		Dog Lake 30 Terrebonne	8–22–57		None	gas	FW. comp. as unperf. gas well.
15,919 14,022	Shell J. T. Caffery 5		Cote Blanche Is. St. Mary	5–21–57 1–13–57		14,022 "I sand	227 B 43.7° 173 mcf 6/64" P 2125	FW. Extended field.
15,924 D & A	Cities Service SL 2709 No. 1	DOC Drlg. Co.	Lafourche	2–20–57 3–25–56			None	WC. Fishing jobs.
15,930 12,804	Rich. & Bass (La. Acct) No. 1 Acadia Sc. Bd.	Dillard & Waltermire	So. Rayne Acadia	3–24–57 6 –8–56	Native 6400' red-9200' lime-oil emul. TD	12,800-4 Miocene	284 B 42° 1215 mcf 1/8" P 8800	FW. Disc. new sand.
16,000 D & A	Shell OCS 0603 No. 1 Block 76	Kerr-McGee	S. Timbalier Lafourche	11–21–57 9–14–57			None	FW. Offshore.
16,000 D & A	Monsanto Girourd 1	Delta Drlg. Co.	Broussard Lafayette	11–30–57 9– 5–57	Oil emul.		None	FW.
16,000 D & A	Mecom LL & E Bay. Chaland 3	Company rig	Plaquemines	7–17–57 1– 1–57	Lime & oil emul.		None	WC.
16,002 12,259	Buffalo Oil J. Manes 1	Falcon-Seaboard	North LeRoy Vermilion	3–12–57 10–22–56	Native 8500' Lime-base TD	12,248–59 Marginulina #7	42 B 48.5° 2511 mcf 1/8" P 7750	WC. Disc. new field
16,005 14,875	Magnolia Hawthorne 1	Brewster-Bartle	Lake Arthur Jeff Davis	6–4 –57 1–10–57	Lime-base	14,865–75 Cibicides Hazardi	56 B 41.7° 3950 mcf 12/64" P 4370	WC. Disc. new field.
16,010 14,265	Texaco SL 2986 No. 2		Caillou Isl. Terrebonne	7–30–57		14,248–56	84 B 57.6° 3025 mcf 11/64"	FW. Extended field.

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft. 2. Prod. depth	Company Well	Drilled by	Field/Area County/Parish	Completed Spudded	Mud program	Perforations in prod. zones	Initial prod., gravity, coke, tubing pressure	Remarks
			LOUISIANA — (Continued)					
16,010 15,014	S. Richardson Amerada C. H. Brookshire Unit 1 No. 1	Dillard & Waltermire	Abbeville Vermilion	1-10-57 7-2-56	Gel mud 10,100′ lime-base oil emul. TD	15,006-12 14,982-91 Miocene	49 B 41.1° 2607 mcf 1/8″ P 9500	WC. Disc. new sand.
16,015 12,006	Rich. & Bass (La. Acct) LeBlanc 1	Company rig	Jefferson Is. Iberia	1-14-57 7-19-56	Gel mud 9500′ lime-base oil emul. TD	12,003-6 Miocene	6 B 48° 2160 mcf 1/8″ P 5750	WC. Extension Disc. new sand.
16,020 D & A	Warren M. A. Patout 1	Clegg & Hunt	Iberia	7- 1-57 2-12-57			None	WC.
16,031 D & A	Drilex Co. A. G. Richard 1	Company rig	Acadia	4-21-57 1- 3-57	Lime-base 8-10% oil 9375′ TD		None	WC. Fishing jobs.
16,044 12,992	Shell-Gall-Miami- Continental	Company rig	Weeks Is. Iberia	10-24-57 5-14-57		12,982-92 "N?" sand	32 B 43.1° 4358 mcf 11/64″ P 4150	FW. Disc. new sand.
16,051 TA	Cities Service SL 2903 No. 2	C. B. Webster	Iberia	4-28-57 12- 4-56			None	WC.
16,107 14,945	Union O & G L. Broussard 1	Gordon Drlg. Co.	Lake Arthur Jeff Davis	12-23-57 8- 7-57	Native 9500′ Lime-oil emul. TD	14,920-45 Miogypsinoides	Gas-cond. Cloud-in 1 1/4″ P 11,300	WC. Extended field. Disc. new sand.
16,145 D & A	Texaco LL & E 50		Golden Meadow Lafourche	12-30-57			None	WC.
16,175 16,116	Texaco SL 117 Terre. Bay		Caillou Is. Terrebonne	11-25-57		16,114-6′	243 B 31.6° 295 mcf 7/64″ P 3000	FW.
16,180 D & A	Olin Gas Trans.		Lafourche	8- 7-57			None	WC.
16,183 13,634	Gulf SL PP 192-114	Rowan Drlg. Co.	Timbalier Bay Lafourche	2- 6-57 9-14-56	16.4# at TD	13,624-34′ Miocene	288 B 30.4° 11/64″ P P 1100	FW. Deepened 14,919 to 16,183′.
16,185 D & A	Pure Oil Alliance Trust 19	Mac Drlg. Co.	Gueydan Vermilion	5-31-57 7-30-56	Lime-base oil emul. 10,054-TD 18# at TD		None	Semi FW. 2 ST-16,185′ max.
16,205 J & A	Magnolia LL & E 1	O.W. Dyer	Lake Hatch Terrebonne	12-10-57 8-12-57	Oil emul. lime-base		None	WC.
16,229 D & A	Superior H. Bourg 5	Company rig	Bay Rambio Terrebonne	4- 1-57 11-11-56	16# TD 1cc water loss		None	FW.
16,252 14,551	Texaco SL 199 Lake Barre, 37-2		Lake Barre Terrebonne	8-11-57		14,545-51	178 B 44.5° 1498 mcf 3/64″ P 4900	FW.
16,290 14,710	Texaco SL 2986 No. 1A		Caillou Is. Terrebonne	3- 5-57 10-17-56		14,710	292 B 27.6° 348 mcf 3/64″ P 2200	FW.
16,342 D & A	Texaco SL 329 No. 21-B		Horseshoe Bay St. Mary	11-18-57 7-22-57			None	WC.
16,347 J & A	Texaco SL 356 No. 1		Bay de Chene 36 Jefferson	10- 6-57			None	FW.
16,350 D & A	Austral A. Prioux 1	Clegg & Hunt	Iberia	11- 2-57 7-20-57	Lime-base oil emul. 9000-TD		None	WC.
16,457 15,608	Humble Anse 41	Gulf Coast Drlg. & Exp.	Avery Is. Iberia	3-27-57 10-11-56	Low solids CMC	15,272-300 15,571-608 Miocene D-3	302 B 39° & 179B 39° 1710 mcf 1/4″ P 1800 & 1250	FW. Disc. new sand.
16,490 P & A	Conoco SL 933 No. A-1	Loffland Bros.	Grand Is. Jefferson	1-13-57 7-12-56	Red lime oil emul. 18# 86 visc. 2.2cc wtr. loss		None	WC. Offshore.
16,500 D & A	Gulf L. Arthur Recl. No. 1	Penrod Drlg. Co.	Grand Lake Cameron	8-13-57 4-11-57	71.8# at TD		None	WC. Stuck core gun at 16,307′
16,500 D & A	Texaco Laterre 49	Wheless Drlg. Co.	Golden Meadow Lafourche	8-23-57			None	WC.
16,502 D & A	Mecom-Freeport SL 2155 No. 2	Company rig	L. Washington Plaquemines	6-20-57 12- 2-56	Lime & oil emul.		None	WC. ST hole kicked from 14,571 to 15,042′.
16,521 D & A	Mecom Pet. SL 3003 No. 1		St. Mary	12-30-57 7- 4-57			Found cond at 14,788-808′	WC.
16,573 —	Texaco SL 199 38 No. 1		Lake Barre Terrebonne	4-26-57			243 B 43.7° 2370 mcf 11/64″ P 4950	FW. Disc. new pay & extension.
16,573 D & A	Shell Cont. Ld & Fur B-3	Company rig	Bat Copasaw Terrebonnne	3-29-57 12-24-56			None	WC.
16,580 D & A	Seaboard J. A. Villien 1	Dixie Drlg. Co.	Maurice Vermilion	10-23-57 5-23-57	Lime-base 17.9#		None	WC.
16,591 TA	Texaco Dog L. Unit 11-2		Dog Lake Terrebonne	2-11-56			None	WC. Fish 15,267′ PB 14,182′
16,610 P & A	CATC SL 933 A-1 OCS 0124	Loffland Bros.	Grand Is. 28 Lafourche	1-14-57 7-12-56	Lime-base oil emul.		None	WC. Drilling tender "J. C. Cleverley" used.
16,690 16,637	Shell "Y" Sand Unit 7 No. 2	Company Rig	Weeks Is. Iberia	7-12-57 12- 4-56		16,637 "Y" sand	146 B 43.7° 8810 mcf 16/64″ P 2950	FW. Extended field.
16,717 Shut-in	Superior-Rockefeller SL 2028 No. 24	Company Rig	Deep Lake Cameron	9-10-57 6-12-56			Gas	WC. in depth. Potential gas producer. Rig off location twice.
16,793 Gas	Texaco LL & E 63		Golden Meadow 71 Lafourche				Gas	FW. Extension.
16,794 D & A	S. Richardson Carbon- Superior Miami 1-	Rich & Bass (La. Acct)	Cote Blanche Is. St. Mary	1-24-57 12-30-55	Native 3000′ Salt 11,800′ lime-base oil TD		None	WC. Orig. hole 16,623′ 2 ST to 16,794 & 16,771′.

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft. 2. Prod. depth	Company Well	Drilled by	Field/Area County/Parish	Completed Spudded	Mud program	Perforations in prod. zones	Initial prod., gravity, coke, tubing pressure	Remarks
			LOUISIANA — (Continued)					
16,810 D & A	Sun E. Moore 1	Company Rig	Rayne Acadia	11- 8-57 5-12-57	Lime-treated oil emul. 16.8#		None	WC.
16,818 13,876	Humble LL & E N-7	Humble Rig 20	L. Hermitage Plaquemines	2- 2-57 9-14-56	Low solids CMC	14,862-76	40 B 36° 4520 mcf $\frac{1}{8}$" P 8400	WC. Extended field.
16,820 15,130	Shell J. A. Smith B-2	Company Rig	Weeks Is Iberia	8- 5-57 4-11-57		15,125-30 "T" sand	202 B 33.9° 514 mcf $\frac{19}{64}$" P 1750	FW. Extended field.
16,935 16,137	Shell J. M. Burgieres Co. 1	Circle Drlg. Co.	Weeks Is. St. Mary	8-23-57 1- 3-57		16,126-37 "U" sand	181 B 42.5° 4076 mcf $\frac{1}{4}$" P 4625	FW. Extended field. Fish 14,690 PB 16,195.
16,960 16,908	Superior Terre. Ld & Dev. 1	Company Rig	Four Isle Terrebonne	9- 6-57 3-20-57		16,898-908	104 B 48.6° 2601 mcf $\frac{18}{64}$" P 5275	WC. Extended field.
17,000 14,555	Tidewater Southdown Sugars #11	John W. Mecom	Hollywood Terrebonne	10- 9-57 5-16-57	High pH Lime emul. 8,586' to TD	14,550-5 upper or middle Miocene	74 B 44.7° 3700 mcf $\frac{12}{64}$" P 4500	FW. Extended field.
17,055 D & A	Pan Am. Pet. SL 3007 #1	Southeastern Drlg Co.	Bastian Bay Plaquemines	12- 5-57			None	FW.
17,212 15,141	H. H. & H. Pet. D. L. Peltier 1	Howell & Howell	St. John Lafourche	9-14-57 5- 3-57	Lime-base oil emul. 17.7# TD	15,090-8 15,102-41 G-3	323 B 46° 3852 mcf $\frac{12}{64}$" P 5125	FW. Disc. new sand.
17,414 D & A	Pan Am. Austral A. Fontenot 2	Drilex Co.	So. Thornwell Cameron	1-11-57 10-12-56			None	WC.
17,634 D & A	Texaco Unit 14 #4		Lake Pelto 28 Terrebonne	3-13-57			None	WC.
17,737 D & A	Texaco E. Cockrell 2		L. Washington 10 Plaquemines	1-12-57			None	WC.
17,768 14,765	W. T. Burton SL 2833		L. Patourde St. Mary	10-23-57 9-17-56		14,744-65	50 B 57.2° 2300 mcf $\frac{12}{64}$" P 3750	WC. Disc. new field. Fish 15,844'. PB 15,400
17,961 14,158	Placid-Pan Am. SL 2857 #2	Penrod Drlg. Co.	Caillou Is. Terrebonne	3-27-57 12-10-56		14,143-58 Miocene	196 B 47.4° 1646 mcf $\frac{8}{64}$" P 4480	WC. in depth. Comp. in field.
18,002 16,842	Pan Am.-Hunt SL 758 #2	Penrod Drlg. Co.	Coon Point Bl. 39 Terrebonne	12- 4-57 5- 2-57		16,828-42	47 B 46.7° 4170 mcf $\frac{12}{64}$" P 4200	WC. Disc. new field offshore.
18,060 15,468	Texaco SL 2856 #1-A		Caillou Is. Terrebonne	5-26-57		15,208-26	142 B 35.6° $\frac{1}{4}$" Gas lift.	FW. Shut in.
18,107 15,226	Texaco SL 301-110		Caillou Terrebonne	2 -9-57		15,208-26	160 B 35.6° 2"	FW. Extension. Gas lift.
19,000 10,626	Shell Antill 1	Company Rig	Humphreys 36 Terrebonne	3-27-57 9-15-56		10,621-26 "Y" sand	186 B 53.6° 3500 mcf $\frac{14}{64}$" P 3400	FW. Disc. new sand.
20,186 19,174	Rich & Bass (La Acct) et al SL 2345 #1	Richardson & Bass	L. Washington Plaquemines	9-14-57 5- 8-56	Lime-base oil emul. Surfac. for completion	19,151-74 Miocene	795 B 39.7° 1735 mcf $\frac{1}{4}$" P 9800	WC. Disc. new sand. Deepened 11,810 to 19,120' PB 11,721-drld to 20,186'
			MISSISSIPPI					
15,277 D & A	Gulf 1-ZB		Soso Jasper				None	WC.
15,380 D & A	Gulf et al J. W. Lott 1	Larco Drlg. Co.	Kittrell Perry	8-24-57 5-18-57			None	WC.
15,715 J & A	Sinclair #1 Miller-Aultman	Marshall R. Young	Covington	7- 6-57 7-10-56	Phosphate 6800' lime-base TD. Diesel oil added to mud slurry, 7% at 12,600'; then Lubekote added to TD		None	WC. Reached 14,209' lost junk; ST at 10,854'.
			NEW MEXICO					
15,115 D & A	Zapata Pet. Danglade		NE Tatum Lea	12-31-57 8-12-57			None	WC. Shows from 3 DST tests—2 below 14,000'.
15,560 P & A	Texaco Muse Fed 1		Lea	4-21-57 6-17-56			None	WC.
15,566 14,736	Conoco Bell Lake 4	Lowe Drlg. Co.	Bell Lake Lea	5-15-57 1-29-56	High pH oil emul. 10.3# wt.	14,736-938 Devonian	64,000 mcf $\frac{12}{64}$" P 5500	FW. Extension. Blowout at 13,393'. Two wks. before brought under control.
16,000	Texaco T. Fletcher A-4		Lea				None	WC.
16,808	Shell James Reh. 1		Eddy				None	WC.
			OKLAHOMA					
15,300 14,953	British-Am. Harrison 2		Grady	11-20-57 9- 6-57		14,947-53	701 B 53° 5350 mcf $\frac{12}{64}$" P 5600	
15,772 15,645	British-Am. Reed #1	Big Chief Drlg. Co.	Carter-Knox Grady	2-11-57 6-13-56		15,575-645 15,220-330	480 B 54.5° 3400 mcf	FW. Extension in 2d & 3d Bromide.
15,815 15,768	British-Am. Baker #1	Helmerich & Payne	Carter-Knox Grady	11-17-57 3-18-57	Oil emul.	15,290-768	135 B 3000 mcf $\frac{1}{4}$" P 2200	FW. Extension in 2d & 3d Bromide.

TABLE 5. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft. 2. Prod. depth	Company Well	Drilled by	Field/Area County/Parish	Completed Spudded	Mud program	Perforations in prod. zones	Initial prod., gravity, coke, tubing pressure	Remarks
			OKLAHOMA — (Continued)					
15,876 15,840	British-Am. Brickel #1	Falcon-Seaboard	Carter-Knox Grady	11-15-57 3-31-57	Oil emul.	15,385-840	Cond. 54° 2500 mcf ¼" P 1400	FW. Extension in 2d & 3d Bromide.
16,708 16,060	British-Am. W. D. Harrison 1-B	Big Chief Drlg. Co.	Carter-Knox Grady	12-20-57 2-20-57	Oil emul.	15,794-16,060	3660 mcf ¼" P 2400	FW. Extension.
17,004 D & A	Pan Am. Mitchell	Big Chief Drlg. Co.	Carter-Knox Grady	12-31-57			None	FW.
17,484 16,630	British-Am. et al S. Krieger #1	Viersen & Cochran	Carter-Knox Stephens	11-21-57 10-13-56	Oil emul.	16,540-630 14,800-15,218	540 B 53° 6600 mcf ⅜" P 3300	Offset. Extended field. Disc. new sand. comp. in 3d Bromide. Deepest production in Okla.
20,446 D & A	Magnolia Sterba-Ordovician 1	Big Chief Drlg. Co.	Cement Caddo	11-25-57				WC in depth.
			TEXAS					
15,015 D & A	Phillips Guinn 1-A	Phillips Rig	Val Verde	3-5-56	Driscose low water loss		None	WC.
15,107 D & A	Ginther, Warren O. W. Williams 1	Dillard & Waltermire	Webb	2-20-57			None	WC. PB 14,197. Abnd. 8-19-57.
15,295 P & A	Humble E. Wardlaw 1	Wesley C. Young	Devils River Val Verde	1-23-57 3-17-56	Red mud. Caustic & Quebracho treated.		None	WC.
15,390 7,750	Rutter & Willbanks Windham 1		S. B. Trend Midland	9-7-57 6-25-57		PB 7750' Clearfork	81 B 37.2° 2" P 7434	FW. Workover.
15,461 4,180	Humble 2nd Nat'l. Bk. of Houston 1	Humble Rig 22	Webster Harris	10-7-57 4-20-57	Lime & gyp Q-Broxin	PC 4170-80 new Miocene	1055 mcf AO P 1595	WC. Disc. gas field. Blowout 2570' while reaming.
15,500 14,747	Phillips O Daniel 1	Penrod Drlg. Co.	Alta Loma Galveston	11-16-57 6-3-57	Wted. low pH Driscose oil emul.	14,656-747 "R-I-A" sand	139 B 52.0° 2098 mcf 5/64" P 9120	FW. Disc. new R-I-A sand.
16,000 14,253	Hassie Hunt Tr. Ben Sass 1	Penrod Drlg. Co.	Alta Loma Galveston	3-5-57 11-12-56		PC 14,247-53	Cond. 51.4° 178 mcf 12/64" P 8618	WC. Disc. new "S" sand.
16,000 6,766	Gulf T. W. Lee 2	Production Maint. Co.	San Salvador Hidalgo	10-8-57 6-7-57	High pH line oil emul.	6726-66 Frio-Vicksburgh	1742 mcf 18 B 60.1° P 1481	WC. below 9500'. Comp. in field.
16,140 8,660	Shell A. V. Traylor B-1	Dillard & Waltermire	Provident City Lavaca	11-15-57 5-23-56	Lime-base oil emul. 9000' to 16,100'	8626-36 adj. P 2000	107 B 59° 4200 mcf adj. P 2000	FW. Wilcox sand. Bankhead Drlg. tested and completed well.
16,525 P & A	El Paso Natural Gas Puckett 1-G		Pecos	7-9-57 6-22-57			None	WC. Orig. drilled by Phillips.
17,444 D & A	J. W. Mecom M. Stewart 13-B	Mecom Rig	Galveston Galveston	3-3-57 2-21-56	Lime & oil emul.		Gas & cond. 15,078-88' P went to 0 on test	WC. Workover attempt unsuccessful.
17,525 P & A	Humble Mills Mineral	Wesley C. Young & Rowan	Pandale Val Verde	5-24-57 4-8-56	Red-Caustic-Queb.-treated		None	WC.
17,880 P & A	Humble 1 W. M. Edwards	Rowan Drlg. Co.	W. Blackstone Pecos	7-29-57 4-24-56	Red-Caustic-Queb.-treated		None	WC.
18,074 J & A	Humble McDonald Lbr. 1	Humble Rig 27	Moss Bluff Liberty	6-11-57 12-18-56	Gyp-Q-Broxin		None	WC. Casing parted 10,466'. Could not pull 75⅝". T./Junk 6785'.
18,771 P & A	Gulf 1-A Northrup		Reeves	6-3-57 9-4-56			None	WC. Deepened
21,687 P & A	Pan. Am. University CS-1	Parker Drlg. Co.	Sec. 27-Blk 23 Pecos	12-2-57 9-27-57	Low pH gel-chemical oil emul.		None	WC. Texas deepest well. Gas show below 14,000'.
			WYOMING					
17,034 16,477	Pure 1 Badwater	Loffland Bros.	Sec. 35 Natrona	11-5-57 5-21-51		15,216-16,477 Cretaceous	5500 mcf ½" P 1700	WC. Shut in gas field. Deepest production in Wyo.

drilled 15,000 ft and deeper.[2]

The record deep well (22,570 ft) cost about $113 a ft and it has since been reworked twice at substantial added cost. Magnolia's Sterba No. 1 Caddo County, Oklahoma, went to 20,446 ft in 1957 at a cost of $51.57 a foot.

Beginning in 1953 deep drilling costs have gone above $40 per ft each year. What it would soar to without constant improvement in drilling methods would be hard to say. It is an achievement that costs have gone no higher despite some deep wells that perform with fishing jobs, blow-outs, lost circulation, and other expensive incidents that expand costs fantastically.

Yearly cost calculations are based on 70 to 80 percent of company figures. All companies that drill three or more deep wells a year have provided costs.

Impressive Achievement

How can you evaluate such a unique accomplishment as the United States petroleum industry's probing of the earth's depths? There have been a few deep wells in other countries, but usually they are drilled by U. S. companies and depend on U. S. experience.

Reports of only one Russian well below 15,000 ft have reached this country and Pravda publishes items about "super-deep" wells between 13,000 and 14,000 ft. Deepest project yet attempted by the Oil Trust is a well at Zyr on the Apsheron Peninsula. Objective is 17,060 ft (5200 meters). Drilling got underway last fall. Deepest penetration for a turbodrill in Russia released for publication so far is 14,632 ft.

Robert Wallace reported the follow-

[2]See "Deeper Drilling Trends Seen in 1957 AAODC Statistics" Page B-125 this issue for drilling costs for all wells. This shows that deep wells cost about three times the average for all wells.

TABLE 6. Deep Well Operators

Operator	Wells drilled 1957	Drilled before 1957	Total
Abercrombie J. S.	0	1	1
Alcoa	1	1	2
American Petrofina	1	0	1
Austral Oil Exploration	1	2	3
Belle Isle Corp.	1	0	1
Brazos Oil & Gas Co.	0	2	2
British American	7	1	8
Brown, J.W.	0	1	1
Buffalo Oil	1	0	1
Burton, Wm. T.	1	0	1
CATC	1	0	1
California Co.	2	1	3
Callery, Inc., F. A.	1	0	1
Chacahoula O & G	1	0	1
Cities Service Producing	2	3	5
Columbian Carbon	1	2	3
Continental Oil Co.	3	10	13
Denver Product & Ref.	0	1	1
Dillard & Waltermire	0	1	1
Drilling & Exploration	1	1	2
El Paso Natural Gas	1	0	1
Flaitz, J. M.	0	1	1
Frankfort Oil Co.	0	2	2
General Petroleum	0	2	2
Ginther, Warren & Ginther.	1	0	1
Gulf Oil Corp.	12	18	30
Hawkins, H. L.	0	1	1
Houston Oil	0	1	1
Howell, Holloway & Howell.	2	1	3
Humble Oil & Ref.	16	25	41
Hunt Group	4	6	10
Husky Oil	0	1	1
LaGloria Corp.	0	1	1
Lamson, Bennett & Cole	0	1	1
Little Nick Oil Co.	0	1	1
Lloyd Corp.	0	3	3
Lone Star Producing	1	0	1
McDermott, J. Ray	1	1	2
Magnolia Pet. Co.	7	24	31
Mayfield, M. L.	0	1	1
Mecom, John W[2]	10	15	25
Mississippi River Fuel	1	0	1
Monsanto (Lion)	1	1	2
Monterey Oil Co.	2	1	3
Mountain Fuel Supply	0	1	1
Ohio Oil Co.	0	1	1
Olin Gas Transmission[1]	4	0	4
Owen, J. P.	0	1	1
Pacific Western	0	1	1
Pan American (Stanolind)	13	24	37
Pasotex Petroleum	0	1	1
Phillips	4	28	32
Placid Oil Co.[1]	2	9	11
Pray, Max	0	2	2
Pure Oil Co.	2	4	6
Quintana	0	1	1
Republic Natural Gas	0	1	1
Richardson & Bass	4	16	20
Richardson, Sid, Carbon	2	5	7
Richfield Oil	0	2	2
Rutter Oil	1	0	1
Seaboard	2	0	2
Shell Oil Co.	13	38	51
Sinclair	1	0	1
Standard of Calif.	3	11	14
Standard of Texas	0	1	1
Sun Oil Co.	3	9	12
Sunray Mid-Continent	1	5	6
Superior Oil Co.	6	23	29
Texas Co.	36	70	106
Texas Gulf	0	1	1
Texas Pacific C & O	1	0	1
Tidewater Oil	5	8	13
Union of Calif.	4	4	8
Union Oil & Gas of La.	3	6	9
Union Producing Co.	0	5	5
Vasen, George	0	1	1
Warren Pet.	4	0	4
Western Natural Gas	0	2	2
Zapata Pet.	1	0	1
TOTALS	199	415	614

[1]One of Hunt Group.
[2]Includes Mecom & Freeport wells.

TABLE 7. DEEP WELL DRILLING CONTRACTORS.

Aldridge & Stroud
Shreveport, La.

American Tidelands, Inc.
New Orleans, La.

Ballew
Fort Worth, Tex.

Bankhead Drilling Co.
Lake Charles, La.

Bell & Burden, Inc.
Los Angeles, Calif.

Big Chief Drilling Co.
Oklahoma City, Okla.

Blackie Drilling Co.
Franklin, La.

Booker Drilling Co.
New Orleans, La.

Brewster-Bartle
Houston, Tex.

Brinkerhoff Drilling Co.
Denver, Colo.

Bullard Drilling Co.
Houston, Tex.

Lyle Cashion, Inc.
Jackson, Miss.

Circle Drilling Co.
Lake Charles, La.

Clegg and Hunt
Houston, Tex.

Coastal Drilling Co.
Bakersfield, Calif.

Corbett Drilling Co.
Odessa, Tex.

Crescent Drilling Co.
Monroe, La.

Delta Drilling Co.
Tyler, Tex.

Delta Gulf Drilling Co.
Tyler, Tex.

Dillard-Waltermire, Inc.
Wichita Falls, Tex.

Dixie Drilling Co.
Dallas, Tex.

Dixie Drilling Co.
Odessa, Tex.

Doc Drilling Co.
Golden Meadow, La.

Drilling & Exploration, Inc.
Los Angeles, Calif.

Dyer Drilling Co.
Lafayette, La.

Harry L. Edwards Drilling Co.
Houston, Tex.

Falcon Seaboard
Lafayette, La.

G. J. Foster Drilling Co.
Richmond, Tex.

Gardner Bros. Drilling Co.
Dallas, Texas

Gilger Drilling Co., Ltd.
Houston, Tex.

C. G. Glasscock Drilling Co.
Corpus Christi, Tex.

Gordon Drilling Co.
Lake Charles, La.

Gracey-Hellums Corp.
Houston, Tex.

Grady Roper
Lake Charles, La.

Gulf Coast Drlg. & Exp. Co.
New Orleans, La.

H. E. T. Drilling Co.
Crowley, La.

Hawkins-Wilkins
Lafayette, La.

Helmerich & Payne
Tulsa, Okla.

Hewgley Drilling Co.
Midland, Tex.

Holmes Drilling Co.
Houston, Tex.

Howell & Howell
Dallas, Texas

Kerr-McGee
Oklahoma City, Okla.

K. L. Kellogg Drilling Co.
Compton, Calif.

Larco Drilling Co.
Jackson, Miss.

Loffland Bros. Co.
Tulsa, Okla.

Lowe Drilling Co.
Midland, Tex.

Mac Drilling Co.
Houston, Tex.

John W. Mecom
Houston, Texas

Mountain States Drilling Co.
Denver, Colo.

Nicklos Drilling Co.
Houston, Tex.

Noble Drilling Corp.
Tulsa, Okla.

Noble Drilling Co.
New Orleans, La.

Norton Drilling Co.
New Orleans, La.

Offshore Drilling Co.
Baton Rouge, La.

Olson Drilling Co.
Tulsa, Okla.

Owen Drilling Co.
Overton, Tex.

Parker Drilling Co.
Tulsa, Okla.

Penrod Drilling Co.
Shreveport, La.

Prince Drilling Co., Inc.
Houston, Texas

Producers Drilling Co.
New Orleans, La.

Production Maintenance Co.
Houston, Tex.

Reading & Bates Offshore Drlg.
Tulsa, Okla.

Richardson & Bass
Fort Worth, Tex.

Rocky Mountain Drilling Co.
Los Angeles, Calif.

Rowan Drilling Co., Inc.
Fort Worth, Texas

J. R. Sharp
Midland, Tex.

Signal Drilling Co.
Casper, Wyo.

Southeastern Drilling Corp.
Dallas, Tex.

Steen Drilling Co.
Houston, Tex.

Sun Drilling Co.
Los Angeles, Calif.

Trans-Texas Drilling Co.
Longview, Texas

Trinity Drilling Co.
Dallas, Tex.

Tri-States Drilling Co.
Laurel, Miss.

Viersen & Cochran
Oklahoma City, Okla.

C. B. Webster Drilling Co.
Houston, Tex.

Well Drillers, Inc.
Houston, Tex.

Western Service Drilling Co.
Longview, Tex.

Wheless Drilling Co.
Shreveport, La.

Marshall R. Young
Fort Worth, Tex.

Wesley C. Young
Sonora, Tex.

Zephyr Drilling Corp.
Tulsa, Okla.

ing in LIFE magazine December 16, 1957:

"Russian drilling rigs available for geophysical studies are remarkably good. At a recent conference in Canada, U. S. Geophysicist Roger Revelle remarked wistfully that it would be nice if a hole could be drilled 10 miles into the earth so that scientists might at least know exactly what lies beneath the submarine and subcontinental coating of basalt. Up spoke a Soviet scientist who said that Russia already has perfected the necessary drilling rig and is only looking for a good place to sink the shaft."

This claim at least produced an excellent forum (Begins on Page B-44) in which nine authorities conclude that a 50,000-ft well can be drilled in the near future if costs aren't counted.

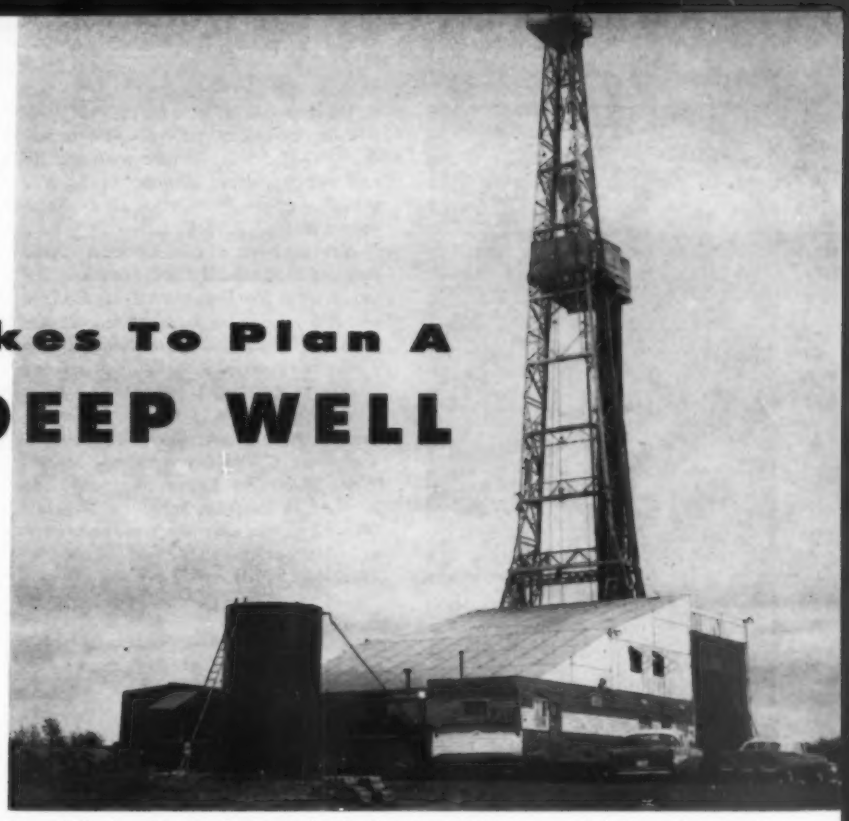
We suggest, however, that it is better to reach depths more gradually, developing and coordinating equipment and methods. It'll be easier to go 10 miles after we've drilled 5 or 6 miles.

Most important, the U. S. petroleum industry has the responsibility of somehow making deep drilling economic. A few more like Weeks Island and Carter-Knox fields will do it, but it takes a lot of oil and gas with good markets to balance the $418 million already spent for 15,000-ft wells. * * *

An engineer's study of . . .

What It Takes To Plan A SUPER-DEEP WELL

R. W. Holman,
Operations Manager,
Howell & Howell,
Dallas, Texas



Howell & Howell's Anadarko Basin No. 1, being drilled by one of the largest and most elaborate land rigs in the country, is projected to drill to 24,000 ft. This depth would surpass the world's deep well record.

P 420.41

Projected to 24,000 ft and engineered for 25,000 ft, three records already broken: (1) Biggest single cement job on (2) longest string of 13⅜-in. casing in (3) deepest 17½-in. hole

Background and Status - - - - - The Editors

NW NW SE, Section 4, T9N, R12W, Caddo County, Oklahoma — *this designation locates some of the most exciting drilling to be found in the industry today. Here, at the Anadarko Basin No. 1, a giant power rig is steadily pushing toward its goal of more than four and one-half miles deep, a depth not yet explored by the drill bit.*

The well is being drilled by Howell & Howell, producers and drilling contractors of Dallas, Texas. Owners of the project are Howell & Howell, Tekoil Corporation, Gulf Oil Corporation, and Kenneth Ellison & Associates.

Located in Oklahoma's vast Anadarko Basin, on the Ft. Cobb anticline, the well is projected to drill to a depth of 24,000 ft in search of the Bromide member of the Ordovician sands. Drilling is presently approaching 10,000 ft with a 12-in. hole after casing 17½-in. hole to 7903 ft with 13⅜-in. special casing and 24-in. hole to 541 ft with 20-in. welded line pipe.

One of the biggest cementing jobs ever done was performed on January 29, 1958, to cement the special-made 13⅜-in., 85 lb-per-ft casing run to 7898 ft. The first batch consisted of 100 sacks of slow-setting cement with 2 percent gel. This was followed by 5000 sacks of portland cement with 12 percent gel, 0.3 of 1 percent retarder, and ⅛ lb-per-sack shredded cellophane. This was in turn followed by 200 sacks of slow-setting cement slurry.

A temperature survey showed the top of the cement to be at approximately 1825 ft. One-inch tubing was run in the annulus to 750 ft and 1000 sacks of portland cement were pumped down this tubing, bringing the cement top to 525 ft. A further batch of 500 sacks of portland cement was then pumped in and approximately 50 sacks of cement were circulated out.

Equipment for the huge cementing job consisted of four pump trucks arranged to mix cement from a total of fifteen storage bins and bulk-cement trucks. Four 400-bbl water tanks, one for each pump truck, were supplied with water from the rig water supply during the course of the job. One line was run from each truck to the rig floor and manifolded into two lines going to the cementing head. Two 6¾-in. by 18-in. rig pumps were lateralled into these lines by lines coming from the rig pump manifold.

Many months of studies and volumes of calculations were completed before rigging up the Anadarko Basin No. 1. Many new and special problems had to be solved before drilling began. Howell & Howell has provided equipment and procedures designed to handle all problems expected to be encountered in drilling this well.

Although the well is projected to drill to 24,000 ft, all engineering plans have been made to drill to 25,000 ft. Here is a report on the planning of this ultra-deep well, prepared by R. W. Holman, operations manager for Howell & Howell and engineer on the Anadarko Basin No. 1, sure to be one of the most closely watched drilling projects since Richardson & Bass set the current world's depth record in Louisiana in 1956.

—The Editors

The author takes notes during world-record cementing job at the Anadarko Basin No. 1.

R. W. Holman, *prior to his present position as operations manager for Howell & Howell, drilling contractors and oil and gas producers, Dallas, Texas, was manager of production for D. D. Feldman Oil & Gas, Dallas.*

He was born at Ida, Louisiana, and finished high school there. He was graduated from Northwestern State College in 1938 with a bachelor of science degree in chemistry and mathematics. In 1940, he received a bachelor of science degree in petroleum engineering from Louisiana State University. Immediately after graduation from Louisiana State University he spent several years with The Texas Company and worked in various positions, the last of which was division reservoir engineer for the South Texas Division in Houston, Texas.

PLANNING THE DRILLING PROGRAM

The drilling program for the Anadarko Basin No. 1 was designed for maximum assurance that the well could be drilled deep enough to test the Ordovician sands which are considered the primary objectives. Since these sands have been prolific producers in other areas, and since it is believed that any production that might be obtained from shallower beds would be relatively much less important, it was concluded that any drilling program that would not give maximum possibility of reaching these sands would be a poor program. With this in mind and taking into consideration the necessity of casing off possible troublesome zones and providing maximum safety for taking care of unknown conditions that might be encountered, the tentative drilling program was set up as shown in Table 1 to drill to a depth of 25,000 ft if necessary.

After the proposed drilling program had been determined, attention was given to the drill pipe and drill collar requirements. It was calculated that in order to derive maximum efficiency from the pumps and bits, the following drill strings would be used to drill the holes:

24-in. hole: 7¾-in. drill collar.

17½-in. hole: 7¾-in. drill collars; 5½-in. drill pipe.

12-in. hole: 7¾-in. drill collars; combination drill string of 4½-in., 5-in., and 5½-in. drill pipe.

8⅝-in. hole: 6½-in. drill collars; combination drill string of 4½-in., 5-in., and 5½-in. drill pipe.

Relative amounts of these various sizes of pipe would be changed from time to time to provide minimum pressure losses due to friction in the drill string and, at the same time, to allow adequate safety factors in tension. Table 4, which shows a combination string designed for a depth of 25,000 ft, presents an example of these calculations.

Several problems result from drilling large holes with small drill collars, and for this reason the most usual practice has been to drill a small hole and then to ream it. There are undesirable features of this practice, however, such as the excessive torque on the drill pipe, and after careful consideration, it was decided that the hole would be drilled initially to full gage. This, of course, necessitates stabilization of the drill collars.

In the Anadarko Basin No. 1, the 8000 ft of 17½-in. hole is to be drilled with stabilization at two drill collars and at seven drill collars above the bit. Weight on the bit is not to exceed 90,000 lb and, of course, will be determined somewhat by the action of the bit and drill pipe. Most of the drilling is expected to be done with a weight on the bit of 75,000 to 85,000 lb and with a rotary speed of 45 to 50 rpm. Essentially the same program will be used for drilling the 12-in. hole.

MUD PROGRAM

The mud program for this well could not be planned entirely beforehand due to a lack of knowledge of conditions to be encountered. It is expected that a natural mud treated with caustic soda and quebracho or other tannins and not to exceed 13 lb per gal will be used to a depth of 18,000 ft, which is as deep as any information is available. It is planned that diesel oil will be added to the mud at approximately 7000 ft.

The mud program below 18,000 ft will have to be determined by conditions encountered. However, if no ex-

Welcome
Location - NW NW SE, Section 4, T9N, R12W
Caddo County, Oklahoma
Owners - Howell & Howell - Tekoil Corp.
Gulf Oil Corp - Kenneth Ellison & Assoc.
Contributors - Many local royalty & landowners
- Superior Oil Co. - Continental Oil Co.
Drilling Contractor & Operator
- Howell & Howell, Dallas, Texas
7903
LEGEND

This impressive sign marks the location of the Anadarko Basin No. 1 and shows drilling progressed to 7903 ft, depth at which 13⅜-in. casing was cemented.

TABLE 1. Proposed Drilling Program — Anadarko Basin No. 1.

Hole	Interval —ft	Hole Size —in.	Casing	Remarks
Conductor	0—540	24	20-in. OD, 72.16 lb per ft	This is line pipe to be welded and cemented to surface.
Surface	540—7900	17½	13⅜ in. OD, 85 lb per ft, N-80, T & C	This string to be cemented to surface.
Intermediate	7,900—19,000	12	9⅝ in. OD, 43.5 lb per ft, FJ	To be set as a liner. Not designed for collapse resistance.
Production String	19,000—25,000	8⅝	7-in. OD, FJ	May be set as liner or as ful string depending upon conditions below 19,000 ft. May become second intermediate string if one is necessary.

tremely high mud weights are necessary, it may be possible to use this same type mud to completion of the well. Temperatures are not expected to be abnormally high and will probably not exceed 330 F.

Depths at which casing points were selected were determined by the necessity to seal off certain possible troublesome formations based on known geology of the area, and to provide maximum safety during the drilling operation. A major factor in determining casing size and hole size was to provide a casing program that would permit drilling through the 7-in. string if unforeseen trouble should develop. As planned, 20-in., Grade B, 72.16 lb-per-ft welded conductor pipe was run to 541 ft and cemented to the surface. A 17½-in. hole was drilled to 7903 ft and a special string of 13⅜-in., N-80, 85 lb-per-ft casing with a wall thickness of 0.608 in. was run and cemented with 6100 sacks of cement.

Below this string, a 12-in. hole will be drilled to approximately 19,000 ft. At this point, 11,500 ft of 9⅝-in., P-110, 43.5 lb-per-ft casing will be run and set as a liner inside the 13⅜-in. casing and cemented with 1000 sacks of cement.

Rubber stabilizer was located seven drill collars above the bit during drilling of 17½-in. hole.

This 17½-in. bit, used in drilling to 7903 ft, helped set a depth record for a hole of this size.

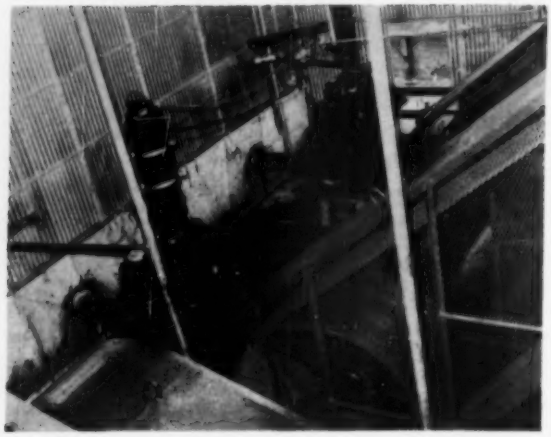
Further stabilization of drill string in 17½-in. hole was provided by three-point reamer two drill collars above the bit.

Beyond 19,000 ft, an 8⅝-in. hole will be drilled to total depth and it is contemplated that 7-in. casing, grade and weight not yet determined, will be cemented to total depth. However, final plans for the 7-in. string have not been completed since many problems can arise prior to reaching total depth of 24,000 ft.

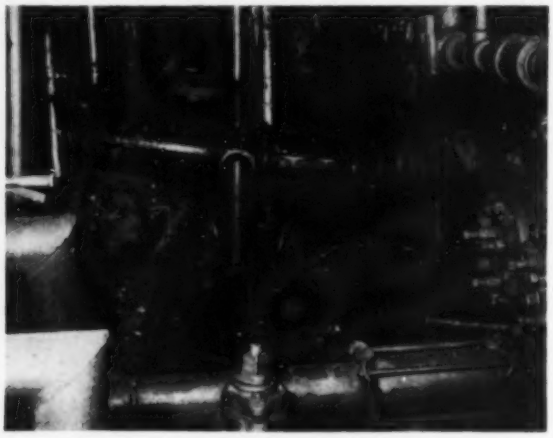
TABLE 2. Tentative Mud Program — Anadarko Basin No. 1.

Interval ft	Mud Weight lb/gal	Viscosity sec	Water Loss cc	Treatment
0-7,000	9.5-9.8	40-45	8-10	Gel, caustic, quebracho
7,000-7,900	9.8-9.9	40-50	5-8	Gel, caustic, quebracho, oil
7,900-9,000	10.0-10.2	40-50	5-8	Gel, caustic, quebracho, oil
9,000-9,150	10.2-11.2	45-55	5-8	Gel, caustic, quebracho, oil
9,150-13,500	11.2	45-55	5-8	Gel, caustic, quebracho, oil
13,500-15,000	11.2-12.5	50-60	5-8	Gel, caustic, quebracho, oil
15,000-19,000	12.5	50-60	5-8	Gel, caustic, quebracho, oil
19,000-T.D.	12.5-12.5+	55-65	5	Gel, caustic, quebracho, oil

Note: Mud program cannot be definitely planned to completion due to lack of knowledge of conditions to be encountered below 17,800 ft.

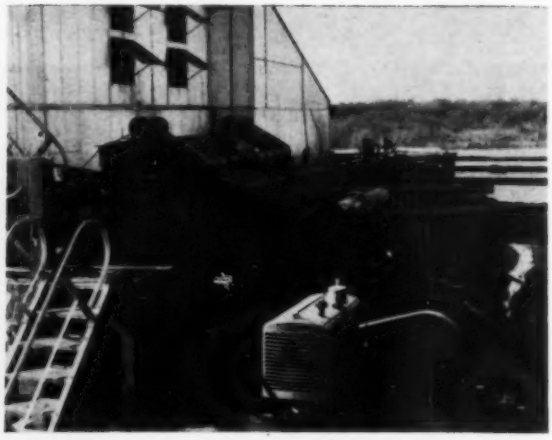


Two 1000-hp, 7¾-in. by 18-in., duplex power pumps are driven from rear section of power compound.



Short, sleeve-type couplings connect the elevated mud tanks to the pumps to provide a flooded suction.

Mud capacity of 1000 bbl is provided by five mud tanks, three of which are shown here. Huge earth reserve pit gives additional capacity.



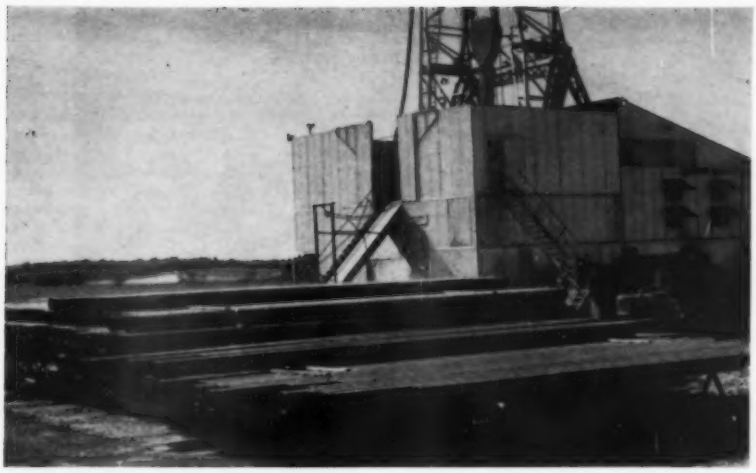
Mud system includes dual-screen shale shaker and a six-centrifuge desander. Jet lines to the right lead to mud reserve pit.

PROPOSED CASING PROGRAM

It is expected that the 19,000 ft depth can be reached without serious difficulty and that the 9⅝-in. string can be run as a liner to this depth. However, beyond this point many unknowns come into the picture, especially geologically, that could make it necessary to set the 7-in. string above projected depth (24,000 ft) and continue drilling inside the 7-in. with a 6¼-in. or 6⅛-in. bit to total depth. In this case, there would remain adequate hole size in which to set a 5-in. liner from 24,000 ft.

Design of 13⅜-in. String

For a basis of calculations, it was desired to design this string for adequate tensile, collapse and burst strength with accepted safety factors in each instance. It became apparent that collapse was the critical consideration. As far as tensile strength was concerned, there was adequate strength in 72 lb-per-ft, N-80 casing to support its weight in air. But, collapse would become critical during later drilling operations if circulation should be lost and the mud level should drop below the bottom of the casing.



Special-order casing is racked at well site before being cemented at 7898 ft in 17½-in. hole. Casing is 13⅜-in., N-80, weighing 85 lb per ft.

Casing crew makes up joint of 13⅜-in. casing. To the left is 8000 ft of 5½-in. drill pipe stacked in the specially reinforced mast.

For design purposes, it was assumed that the casing would be empty on the inside and would have 9.625 lb-per-gal mud on the outside. The calculated collapse pressure in the critical section of the 13⅜-in. casing was estimated at 4000 psi, far above the strength of N-80, 72 lb-per-ft casing.

The ratio of diameter to wall thickness, or the d/t ratio, of the 72-lb, N-80 casing was 26.02. Calculations indicated that for the collapse resistance desired, a d/t ratio of 22 would be required. It was indicated that use of a higher grade of steel would not accomplish the desired collapse resistance in the standard casing weights and that the best solution would be to increase the wall thickness.

To attain a d/t ratio of 22, it was necessary to increase the wall thickness of the 13⅜-in. OD, N-80 casing to 0.608 in. This pipe was especially manufactured at the mill for the job.

The finished casing had an outside diameter of 13⅜ in. and an internal diameter of 12.159 in. Drift diameter was 12.003 in. The calculated total weight of the 8000-ft string in air was 680,000 lb. Calculated weight when filled with a 9.625 lb-per-gal mud was 596,000 lb. Joints were regular API couplings, eight round threads per inch, which provided a safety factor in tension of 1.51 in air. When the casing was run, it was equipped with a differential fill-up float collar and float shoe.

Design of 9⅝-in. String

It was recognized that since it may be necessary to bring the production string all the way back to the surface, a full string of 9⅝-in. casing would not be necessary and could be set as a liner inside the 13⅜-in. casing. With the 13⅜-in. casing set to 7898 ft and bottom of the 9⅝-in. casing at 19,000 ft, an 11,500-ft string of the 9⅝-in. casing would extend about 400 ft up into the 13⅜-in. casing, providing ade-

Weight indicator shows the load of more than 625,000 lb registered while running 7898 ft of 13⅜-in. casing.

Partial view of cementing operations shows two of the four pump trucks used in the tremendous job of cementing casing. Fifteen bulk-cement carriers brought in 6100 sacks of cement used in the job.

Courtesy, Halliburton Oil Well Cementing Company

quate overlap for a good seal and support.

In order to provide adequate tensile and collapse strength, it was necessary to use Grade P-110, 43.5 lb-per-ft casing throughout the string, using a flush joint type connection to provide better clearance in the open hole.

No attempt has been made to design the 7-in. string because of the uncertainty of conditions that will be encountered that would influence the design of this string.

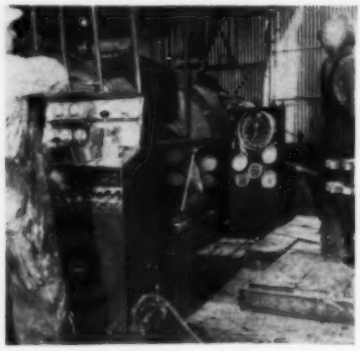
TABLE 3. Proposed Casing Program — Anadarko Basin No. 1.

Size in.	Grade	Weight lb/ft	Joints	Length set ft	Depth Set ft	Cementing procedure
20	B	72.16	Welded	540	540	Cemented to surface.
13⅜	N-80	85	T & C	7900	7900	100 sacks slow-setting cement with 2% gel; 5000 sacks portland cement with 12% gel, 0.3 of 1% retarder, and ¼ lb per sack shredded cellophane; 200 sacks of slow-setting cement; 1000 sacks of portland cement pumped down casing annulus and circulated to surface.
9⅝	P-110	43.5	FJ	11,500	19,000	1000 sacks slow-setting cement.
7	*	*	FJ	*	25,000	*

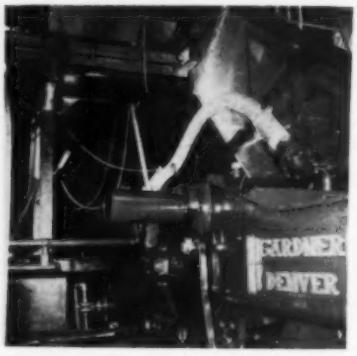
*To be determined when conditions are known.

DRILLING EQUIPMENT

One of three 867-hp, V-12 engines supplying rig power.



Compact driller's console provides fingertip control of operations.



Power end of one of mud pumps showing caged-in V-belt drive from compound and discharge mud line to manifold.

Drill Pipe

Drilling the Anadarko Basin No. 1 to 24,000 ft will be accomplished, as proposed above, using a telescoping string of drill pipe and drill collars. The following lengths of drill pipe and collars have been secured for the drilling program:

16,000 ft of 4½-in. OD, 16.6 lb-per-ft, X-95, internal upset seamless pipe, with 6-in. OD, square shoulder, full hole, hard-faced tool joints.

6000 ft of 5-in. OD, 19.5 lb-per-ft, X-95, internal upset seamless pipe, with 6¼-in. OD, square shoulder, full hole, hard-faced tool joints.

8000 ft of 5½-in. OD, 24.7 lb-per-ft, X-95, internal-external upset seamless pipe, with 7-in. OD, full hole, hard-faced tool joints.

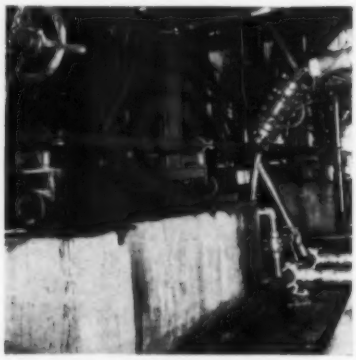
27 joints of 7¾-in. OD by 3¼-in. ID, integral connection drill collars, with 6⅝-in. flexible regular integral box and pin.

Power

Power for the drawworks and two pumps is provided by three 867-hp, V-12 gas engines with diesel engine pistons. The three engines are connected to a high-speed sectional power-end compound with direct drive to the drawworks and a rear-mounted 1000-hp double mud pump drive.

Propane is used as fuel for the engines.

Large mast has been specially reinforced to cope with huge loads encountered in drilling and running casing.



Foundation consists of 40-ft by 90-ft by 2-ft slab and two 3-ft by 8-ft by 34-ft beams. Reinforced substructure raises rig floor to 20 ft aboveground.

Shale shakers and desander will remove almost 25,000 cu ft of cuttings from the mud system in drilling to 24,000 ft.

Facts ON Visco® CORROSION PREVENTION

Here are facts on Visco Corrosion Inhibitor costs in a wide variety of producing oil and gas wells—probably some near you . . . or with corrosion problems like yours. At every well, Visco treatment is only a small fraction of the cost of corrosion damage in untreated wells.

WELL TYPE	WELL LOCATION	DAILY PRODUCTION			Frequency of Visco Treatment	Cost of Visco Treatment per bbl of produced fluid
		Oil bbls	Water bbls	Gas MCF		
Pumping	East Texas	40	300	—	3 times a week	.13¢
Pumping	Eastern Kansas	2	492	—	Once a week	.03¢
Flowing	West Texas	20	6.3	—	Twice a week	.22¢
Pumping	Northern Kansas	10	70	—	Once a day	.62¢
Gas Lift	West Texas	20	20	—	Once a day	2.8¢
Pumping	North Texas	—	2000	—	Once a day	.16¢
Pumping	Eastern Kansas	—	250	—	Twice a week	.11¢
Flowing	East Texas	51	155	1	Once a day	.28¢
Flowing	West Texas	420	—	—	Twice a week	.13¢
Gas	East Texas	25	Trace	22.9	Twice a week	4.6¢*
Pumping	West Texas	420	210	—	Every other day	.14¢
Pumping	West Texas	441	441	—	Every other day	.052¢
Gas	Northern La.	—	—	23.4	Once a day	2.42¢*
Pumping	Eastern Kansas	—	250	—	Once a day	.15¢
Pumping	Kansas	100	948	—	Twice a week	.13¢
Gas	Louisiana	9.2	Trace	300	2 Sticks every other day	.66¢*
Pumping	East Texas	46	176	0.92	Once a day	.27¢
Pumping	East Texas	51	155	1.0	Once a day	.28¢
Pumping	East Texas	20	400	—	Three times a week	.12¢
Pumping	Eastern Kansas	2.5	276	—	Once a week	.09¢

*Cost in cents per million cubic feet.

Stick type treatment is easily applied through simple fitting added to well head.

Some producers mount a pump and tank of inhibitor on a small truck, make a regular circuit of leases to pump inhibitor into their wells.

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Drawworks

The drawworks on the Anadarko Basin No. 1, rated at about 1800 input horsepower, is one of the largest available. The 32-in. by 56-in. drum was specially grooved for the 1⅜-in. wire line.

An electro-magnetic brake on the drawworks provides easily controlled braking effect variable from high speeds to a drum speed slow enough to set slips safely on the heavy casing strings to be run.

TABLE 4. Example Calculations of Combination Drill Pipe Design — Anadarko Basin No. 1.

Interval ft	Length of interval ft	Size of drill pipe in.	Weight of pipe lb/ft	Weight of interval lb	Weight of interval less mud buoyancy lb	Cumulative weight lb	Tensile strength of pipe body lb	Safety factor in tension
25,000–24,100	900	6½	85.0	76,500	62,800	62,800	—	—
24,100– 8,100	16,000	4½	16.6	266,000	618,000	280,800	418,730	1.49
8,100– 4,000	4,100	5	19.5	80,000	65,500	346,400	501,080	1.45
4,000–0	4,000	5½	24.7	99,000	81,400	427,800	629,850	1.47

DATA: Depth—25,000 ft; Mud Weight—14 lb per gas; Drill Collars—thirty 6½-in. OD by 3¼-in. ID.

Pumps

There are two 7¾-in. by 18-in. duplex power pumps, each rated at 1000 hp and driven by the end section of the power compound. In addition there is one 7¾-in. by 16-in. duplex power pump, one 5-in. by 8-in. power pump, and a rotary pump for pumping water.

Drilling Mast

The 25-ft by 142-ft mast has been reinforced by additional bracing to increase the hook-load capacity to 800,000 lb. The racking board has been increased in size to accommodate 25,000 ft of a combination string of drill collars and 4½-in., 5-in., and 5½-in. drill pipe. The racking area of the substructure has been reinforced to support the load of the 25,000 ft of pipe and also to support the load of 19,000 ft of drill pipe and drill collars racked in the mast while a 19,000-ft string of 9⅝-in. casing is hanging on the rotary table.

Foundation

The rig is mounted on a reinforced concrete foundation consisting of a 40-ft by 90-ft slab 2 ft thick and two 3-ft by 8-ft by 34-ft beams. Fifty thousand lb of steel reinforcing rods and 370 cu yd of concrete were used in the construction of the foundation.

The engine substructure is 10 ft high and the derrick substructure is 16 ft high, and both are mounted on the 3-ft high beams of the foundation. The derrick floor is therefore 20 ft above ground level, providing adequate room for all the blowout prevention equipment and giving additional room for a circulating head if it is needed.

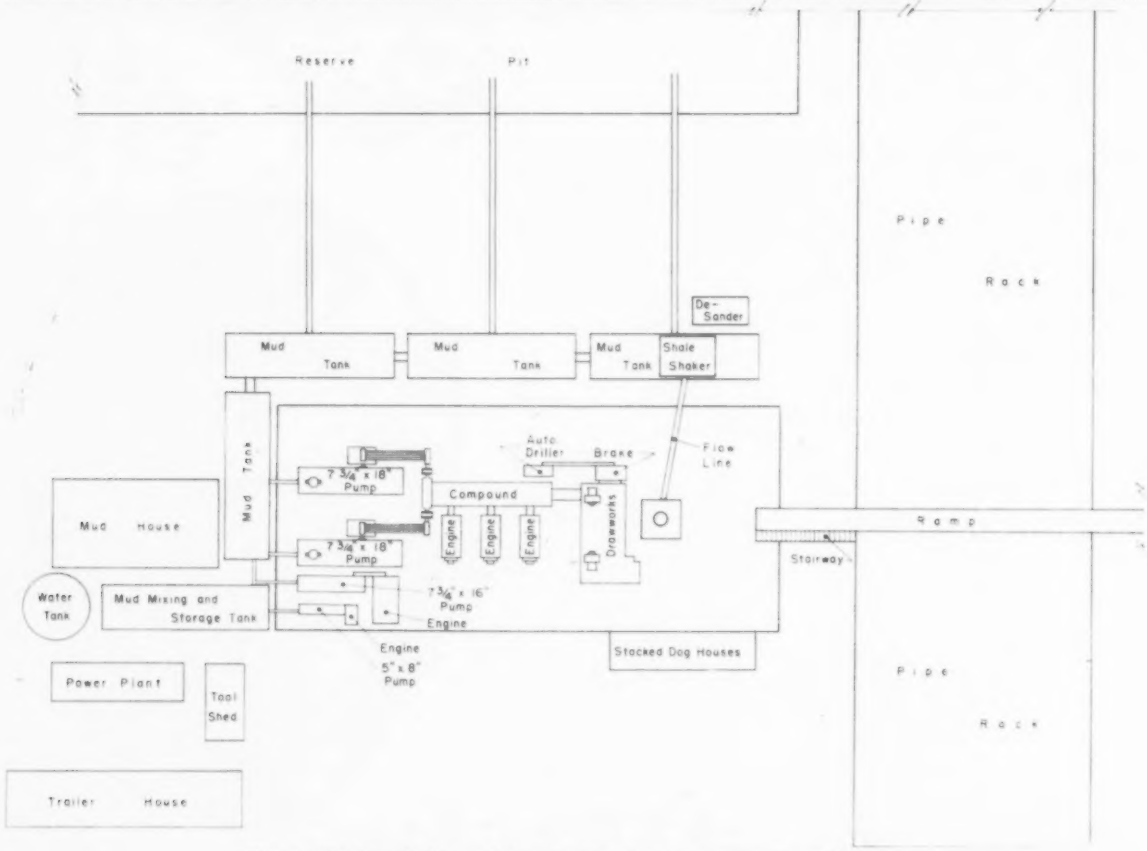


FIG. 1. **Rig layout** shows relative position of major components of Howell & Howell's Rig No. 9, drilling the Anadarko Basin No. 1 in Caddo County, Oklahoma.

Sectional steel building completely encloses engines, pumps, and derrick substructure. Three stacked dog-houses at right provide tool house, crews' locker room, and floor-level control room. In the foreground is one of five blowout preventers provided for the rig.

H. T. "Red" Howell, toolpusher, checks on operations registered on one of two recorders in dog-house.

Large reel held 10,200 ft of 1⅜-in., 6 by 19 wire line. At right is racked the special-order 13⅜-in. casing.

Mud System

In addition to the pumps and lines, the mud system has five 200-bbl steel tanks, four of which are used to handle the mud being circulated, while the fifth is a mud mixing and storage tank. This makes it possible to mix a tank of mud to the proper specifications before it is added to the total system and also provides standby storage if desired.

Dual-screen shale shaker is powered by two 3-hp electric motors and is used in conjunction with a six-centrifuge desander having a fluid capacity of 800 gal per min at 35 psi feed pressure.

All of the pump suctions on the rig are made of pipe instead of flexible rubber hoses as is customary. These suctions have been made as short as possible and are connected by sleeve type slip-on couplings which provide a certain amount of flexibility. Mud tanks are raised approximately nine inches above ground level, allowing the suctions to be placed in the bottom of the tanks for maximum use of the mud volume in the tanks and also providing a slightly increased head on the pump suctions to assure flooded suctions.

Engine Housing

The engines, derrick substructure and pumps are completely housed in a sectional steel building. Also, there is a 12-ft high wall around the derrick floor which provides protection for the crews during bad weather.

Blowout Preventers

Five blowout preventers are provided for this rig. They contain blank rams, rams for 4½-in., 5-in., and 5½-in. drill pipe, and a bag type hydraulically operated blowout preventer that will seal around the kelly, any size pipe, or close the open hole.

Recording Equipment

Electrical recording equipment is provided which records pump pressure, pump strokes per minute, weight on the bit, penetration rate, rotary speed and relative torque.

Additional Drilling Equipment

Traveling block. 500 ton; six 50-in. diameter sheaves; forged steel rim sheaves; 1⅜-in. grooves.

Elevators. 7¼-in. center latch; for 4½-in., 5-in., and 5½-in. drill pipe.

Swivel. 400 ton dead load capacity; 200 ton maximum rating at 100 rpm.

Hook. 500 ton rated capacity.

Kelly. 5¼-in. by 40-ft upset hexagonal; 6⅝-in. pin and box connections.

Automatic Drilling Control. Multicylinder pumps powered by drawworks drum and connected to drumshaft through electro-magnetic brake.

Wire Line. 10,200 ft; 1⅜-in., 6 by 19 plow steel.

FORMATION EVALUATION

It is expected that electric logs will be run over the entire section of the hole and micrologs run on selected intervals. A mud logging unit will be placed on the rig at approximately 15,000 ft to provide information helpful in controlling the drilling operations and possibly provide some aid in formation evaluation.

It is anticipated that little coring or drillstem testing will be done, particularly in the upper part of the hole since the upper formations are considered to be of relatively less importance than the objective Ordovician sands.

WELL COMPLETION

No tubing string completion program or well head equipment has been designed for the well due to the lack of knowledge of conditions that will be encountered. It is anticipated that if production is obtained it will be gas-condensate. Design of the tubing and well head equipment will depend upon the pressures encountered as well as the volume to be handled, both of which will probably be determined by drillstem testing prior to completion of the well.

SPECIAL PROBLEMS

Several problems arose in the planning of this super-deep well that are not encountered in drilling shallower wells.

Hydraulics

With both of the duplex power pumps pumping mud while the 17½-in. hole is being drilled, only about two-thirds of the circulation rate usually considered necessary could be supplied. Therefore, drilling mud of a quality superior to that customarily used will be used in the upper part of the hole.

Hydraulics is also a problem as the hole is drilled deeper due to excessive friction losses in the drill pipe and drill collar string. By the use of a combination string of drill pipe which includes 4½-in., 5-in., and 5½-in. pipe, and using drill collars with a 3¼-in. inside diameter, friction loss will be reduced so that surface pressures on the standpipe will not exceed 3000 psi, which is considered to be about the upper limit at which the pumps can be operated without a considerable amount of breakdown time. Table 5 is a calculation of hydraulic losses which might prevail in drilling at 25,000 ft with the combination drill string.

Straight Hole

Due to the great difference between the size of the 7¾-in. drill collars to be used and the 17½-in. hole, it was necessary that plans be made to stabilize the drill collars in order that enough weight could be applied to the bit to

achieve satisfactory penetration rates. Plans call for the use of twenty-seven 7¾-in. OD by 3½-in. ID drill collars stabilized with one three-point reamer two drill collars above the bit and a rubber stabilizer seven drill collars above the bit. Maximum weight to be placed on the bit is 90,000 lb and rotary speeds are to be 45 to 50 rpm. Essentially the same program is to be used for drilling the 12-in. hole except that stabilization will be achieved with two rubber stabilizers instead of one reamer and one rubber stabilizer.

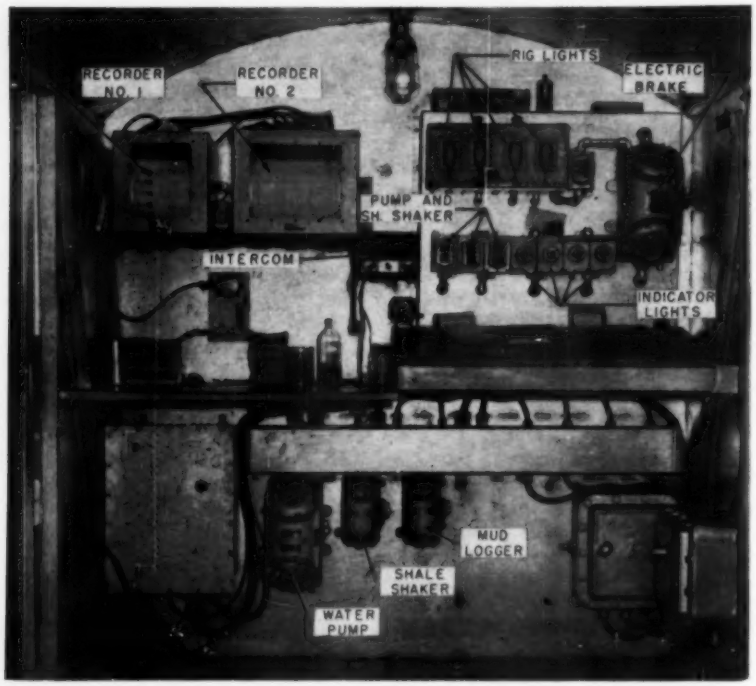
TABLE 5. Hydraulic Data — Anadarko Basin No. 1.
Calculations of Approximate Conditions at 25,000 ft
Howell & Howell Rig No. 9 — Caddo County, Oklahoma.

DATA:

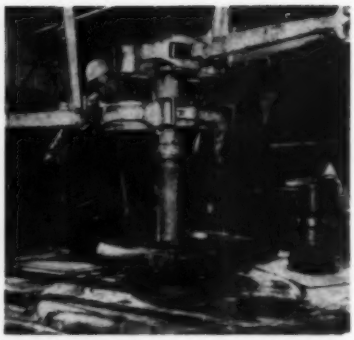
Pumps: 2 duplex power pumps, 5-in. liners, 18-in. stroke, 45 spm.
Standpipe: 65 ft of 3.826-in. ID pipe.
Hose: 60 ft of 3-in. hose.
Swivel: 3-in. ID
Kelly: 40 ft of 4-in. ID pipe
Other piping: 80 ft of 3.826-in. ID pipe.
Drill pipe: 900 ft of 6½-in. OD by 3¼-in. ID drill collars.
16,000 ft of 4½-in. OD drill pipe.
4,100 ft of 5-in. OD drill pipe.
4,000 ft of 5½-in. OD drill pipe.
Bit: Three 5/8-in. bit nozzles.
Lower hole size: 8⅝-in.
Mud: 14 lb-per-gal, oil emulsion mud.
Circulation rate: 395 gal-per-min at 90 percent efficiency.

Estimated Pressure Losses

Mud course	Lb per sq. in.
Through surface equipment	30
Through 4000 ft of 5½-in. drill pipe	126
Through 4100 ft of 5-in. drill pipe	216
Through 16,000 ft of 4½-in. drill pipe	1465
Through 900 ft of 3¼-in. ID drill collars	175
Through bit nozzles	238
Around 900 ft of 6½-in. OD drill collars in 8⅝-in. hole	70
Around 5100 ft of 4½-in. drill pipe in 8⅝-in. hole	89
Around 10,900 ft of 4½-in. drill pipe in 9⅝-in. casing	168
Around 600 ft of 5-in. drill pipe in 9⅝-in. casing	12
Around 3500 ft of 5-in. drill pipe in 13⅜-in. casing	5
Around 4000 ft of 5½-in. drill pipe in 13⅜-in. casing	6
Total hydraulic pressure loss, psi	2600



Control panel in dog-house contains electrical controls and indicating instruments. Recorders show pump pressure, pump strokes per minute, rotary speed, hook load, rate of penetration, and relative torque.



Breaking out 5½-in. drill pipe when drilling record-breaking 17½-in. hole.

Drill Pipe

It was only through the use of combination drill pipe string of high grade pipe that safety factors in tension could be obtained that are considered adequate. See Table 4.

Casing Design

One of the problems in deep hole drilling is obtaining casing with properties that will provide adequate safety factors. It was necessary to have manufactured special 13⅜-in., 85 lb-per-ft casing to provide adequate collapse resistance for setting at 7900 ft. Setting casing to this depth was considered necessary due to formation characteristics and the possibility that returns would be lost while drilling below this depth.

Heavy Loads

Several problems arose in planning to handle the excessively heavy loads that would be imposed upon the rig during the setting of the 7900 ft of 13⅜-in. casing, and the setting of the 9⅝-in. casing as a liner from 7500 ft to 19,000 ft. For instance, in the case of the 13⅜-in. casing, it was found that only one manufacturer made an elevator that had a load rating of more than 200 tons. This elevator, which has a rating of 300 tons with a safety factor of 2.3, was the only one suitable for handling the estimated load of 625,000 lb.

Quite a problem is posed by the plan to set the 9⅝-in. casing as a liner which would mean that it would be run on the 5½-in. drill pipe. The estimated weight of this string, plus the weight of the drill pipe, less the buoyancy of the mud, is 577,000 lb as compared to the body strength of the drill pipe of 625,850 lb. This gives a safety factor of only 1.09, which is considered much too small.

Although plans have not been worked out completely for the setting of this string of pipe, it is anticipated that it will be partially floated in and hung on the 13⅜-in. casing before it is filled completely with mud so that the safety factor in tension will be great enough for reasonable safety. ★ ★ ★

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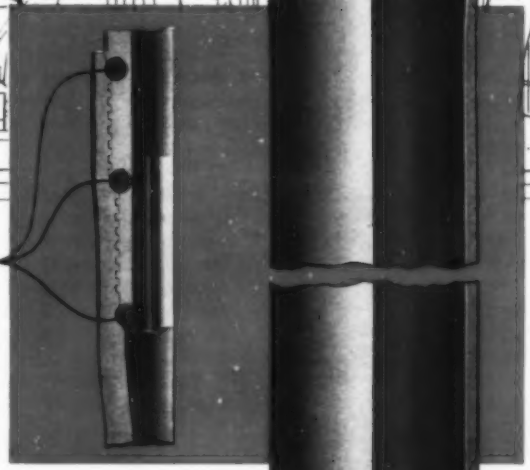

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AOSC SHAPES

NEW ROLE OF THE SERVICING CONTRACTOR

Young organization counts rapid growth and service to an unrepresented segment of the oil industry

ORGANIZATION cultivates understanding and progress; this statement was proved by 250 attending the second annual convention of the Association of Oilwell Servicing Contractors in Dallas recently.

In slightly more than two years, the AOSC has made valuable contributions to the welfare of member contractors and has given stature to the contractors as a whole.

Attesting to its worth is the rapid growth of AOSC, which now has 10 active chapters in New Mexico, Louisiana, Mississippi, Arkansas, and Texas. It is the sole organization speaking for a previously-unrepresented segment of the industry composed of some 2000 oil well servicing contractors. They operate approximately 8000 well servicing rigs valued in excess of $250,000,000. It is estimated that servicing contractors in the U. S. and Canada do a gross business of more than $200,000,000 annually.

The Two-Year Record

Growth of AOSC has been phenomenal. It was founded in 1956 with only 13 members. It now counts 200.

Frank Bateman of Hobbs, New Mexico, contractor and president of the AOSC in 1957, gave a progress report of the group's activity. Of particular note, says Bateman, is that relations among oil well servicing contractors had improved noticeably in the past year without any sacrifice of independence or independent action. "There is improved prestige for our part in the oil industry," states Bateman.

Weight laws: Bateman cited several examples where the organization had brought about action favorable to contractors as a whole. "A new weight law in Texas has been passed by the state legislature, for which the AOSC can take full credit, easing the strain by raising load limits. The existing weight law had limitations that made it difficult for servicing contractors to move their equipment on the highways."

Fuel tax: "Another example occurred in New Mexico. The legislature of that state, probably without realizing the injustice done to well servicing contractors, passed a law imposing a tax of six cents per gallon on butane and other special motor fuel used in any registered vehicle. As a highway usage tax, it was one thing; but as a tax on well servicing units that might be in operation for days and even weeks at one location—never touching a highway — it was something else again. AOSC efforts brought about an interpretation of the law by the New Mexico attorney general, recognizing the situation and providing relief for firms in our field. The tax now is computed through the use of hubometers."

Theft control: A third example pointed out by Bateman concerned the theft and pilferage of contractors' material and equipment, which had become a major problem. Through a new theft and pilferage control program, says Bateman, "each member contractor is given an identification number with which to brand his tools. If he has a loss, he reports it to the association office and the loss is reported quickly to all law enforcement agencies in the area." This program has led to the arrest of several groups. Reports of thefts have now declined to a minimum.

Accident reporting: A system of accident reporting has been initiated. Each time an accident occurs to a member's employee, a copy of the accident report is mailed to the central AOSC office. These reports form a basis for studies on the many phases of accidents. From these, it is hoped that much can be learned to determine causes and to effect a cure.

Future Aims

Safety: An accelerated safety program is receiving top priority on the agenda of AOSC's 1958 work sheet. An improvement in the overall safety record of the well servicing industry is being sought so as to affect a reduction in workmen's compensation insurance rates.

Public relations: AOSC will expend time, effort, and money this year to effect better relations with its customers, other contractors, other segments of the oil industry and with the general public, Bateman suggests.

Labor turnover: One of the major problems in the business is that of labor turnover. Steps are being taken to improve the quality of workmen and workmanship, and to insure the permanency of employees on the job. This program is in the incubation stage.

Accounting: Committees of the young organization are hopeful of instituting a uniform accounting. Such a system could provide the basis of comparison or work and work limits for the purpose of guiding management of contractor firms.

J. F. McAdams, new AOSC president, took the reins of office from Frank Bateman at the group's recent annual convention in Dallas.

Legislation: AOSC officials hope to have, someday in the not-too-distant future, a qualified person to represent the organization before insurance boards, legislative groups, rate-making bodies and similar organizations.

Growing Pains

Servicing contractors are noting the contributions made by AOSC and realizing the potential. A new chapter is in organizational stages in Oklahoma. Other inquiries concerning membership are being received frequently from California, Illinois, Pennsylvania, and New York.

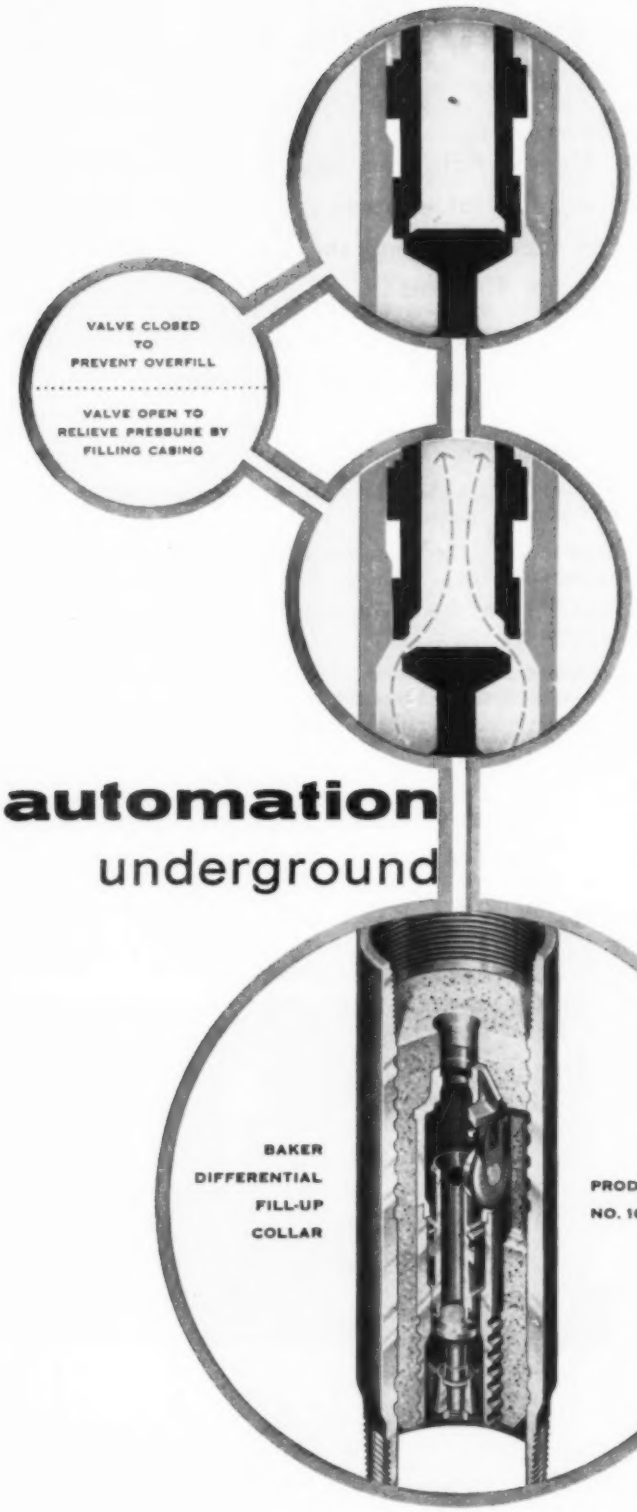
To Guide the Growth

To put action to the plans made at the Dallas meeting, guiding AOSC growth and policy a new slate of officers have been elected. J. F. McAdams, general oilfield contractor of Hobbs, New Mexico, was chosen president. J. C. Williams Jr., of the J. C. Williams Well Servicing Company, Springhill, Louisiana, was named first vice president. Second vice president is Thomas E. Goebel, Spur Well Servicing Company of Houston. Jimmy Wilkins, Permian Servicing Company, Levelland, Texas, was re-elected treasurer. Woodie Fox has been renamed the association's executive secretary.

A Bright Future

Contractors attending the convention displayed optimism, and as a group, suggested an upward trend in the oil industry this year. Its members are predicting a particularly good year for their segment of the industry, based on an increased emphasis by most companies for holding and building production from existing wells through well service and well workover. ★ ★

BAKER DIFFERENTIAL FILL-UP EQUIPMENT HAD "WHAT IT TAKES" FOR RECORD 7,898-FOOT 13⅜-INCH CASING STRING



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Inclusion of a Baker Differential Fill-Up Shoe and Collar in their plans for the longest string of 13⅜" casing ever run paid off for Howell and Howell in their Andarko Basin No.1. The record 7,898-foot string was landed without incident, dramatically demonstrating the advantages, reliability, and safety of Baker Differential Fill-Up Equipment.

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If economics were not a factor . . .

COULD WE DRILL A 50,000-FT HOLE?

Although high anticipated temperatures might be a deterrant, a panel of experts agreed that the U.S. oil industry has the equipment and know-how to penetrate the earth nearly 10 miles

A reported claim that the Russians already have a rig capable of drilling 10 miles into the earth prompted the American Society of Mechanical Engineers' South Texas Section, Petroleum Branch, to examine America's prospects of reaching such a depth.

Eight experts in various phases of drilling told ASME members at a meeting in Houston, Texas, January 8, 1958, that a 50,000-ft well could be drilled, provided a number of problems are solved. And the U. S. oil industry is confident that it can solve these problems, the experts said.

The economics of drilling a 50,000-ft well were intentionally omitted. Only the mechanical and technical phases of the problem were considered.

The Petroleum Engineer acknowledges with many thanks permission granted by the South Texas Section of the ASME to publish the complete transcript of this highly informative and interesting panel discussion.

Much credit for this outstanding panel discussion should go to Bill Boyd, Gulf Oil Corporation, Houston, who as program chairman conceived the idea for this subject.

Topics discussed and speakers were:

1. **Earth Conditions** . . . Paul Weaver, Texas A&M professor and former geophysicist for Gulf Oil Corporation, Houston.
2. **Casing and Drill Pipe** . . . Sheldon Reynolds, engineer, National Tube Division, U. S. Steel Corporation, Houston.
3. **Rig Equipment** . . . Jack Abernathy, vice president, Big Chief Drilling Company, Oklahoma City.
4. **Drilling Fluid** . . . O. W. Van Dyke, vice president, Magnet Cove Barium Corporation, Houston.
5. **Electrical Logging** . . . W. B. Steward, assistant to vice president of engineering, Schlumberger Well Surveying Corporation, Houston.
6. **Drilling Bits** . . . Lyle Payne, assistant vice president — engineering, Hughes Tool Company, Houston.
7. **Cementing** . . . W. D. Owsley, senior vice president, Halliburton Oil Well Cementing Company, Duncan, Oklahoma.
8. **Operations** . . . Thomas Pennington, Jr., senior supervisor drilling engineer, Humble Oil & Refining Company, Houston.

Panel Moderator . . . W. E. Boyd, division drilling engineer, Gulf Oil Corporation, Houston.

Panel of deep drilling experts who examined the question: "Could We Drill A 50,000-ft Hole?" at a recent South Texas Section ASME panel discussion. At left, **Edward DeJon,** Johns-Mansville Corp., Houston, chairman, South Texas Section, ASME; **Lyle Payne,** assistant vice president — engineering, Hughes Tool Co., Houston; **Sheldon Reynolds,** engineer, National Tube Div., U.S. Steel Corp., Houston; **Thomas Pennington, Jr.,** senior supervisor drilling engineer, Humble Oil & Refining Co., Houston; **Jack Abernathy,** vice president, Big Chief Drilling Co., Oklahoma City; **W. E. Boyd,** division drilling engineer, Gulf Oil Corp., Houston; **W. B. Steward,** assistant to vice president of engineering, Schlumberger Well Surveying Corp., Houston; **W. D. Owsley,** senior vice president, Halliburton Oil Well Cementing Co., Duncan, Okla.; **O. W. Van Dyke,** vice president, Magnet Cove Barium Corp., Houston, and **Paul Weaver,** Texas A&M professor and former chief geophysicist, Gulf Oil Corp., Houston.

EARTH CONDITIONS ... **Paul Weaver,** Texas A&M Professor and former chief geophysicist, Gulf Oil Corporation, Houston, Texas.

Paul Weaver

Briefly, I am going to restrict my remarks on earth conditions to one aspect: Temperature. The reason for this restriction is that the subject of the earth's strength at great depth has been the theme of many publications. But the subject of temperature has not received the same amount of treatment, and I think it is more important than other factors because everything you put down the hole has to be tailored to the temperature you are going to meet while drilling.

What can we say about temperatures at 50,000 ft? I have considered many different computations of earth temperature that have been made and I come out with the figure that, at 50,000 ft, we should be dealing with temperatures between 450 F and 700 F, subject to the following assumptions: (1) We are drilling in deep sedimentary basins where there has been no great amount of movement in a long geologic period, other than the sinking of the basin. (2) We have no big young heat sources in the form of either igneous intrusions or large salt masses close to where we propose to drill. (3) We are considering only sandstones and shales with limestones and dolomite and with the shales predominating. (4) We are assuming that we are dealing with sediments not subject to exothermic reaction due to their position in depth.

All of these assumptions are valid for deep basins such as those in Utah, Nevada, the San Joaquin Valley in California, the Gulf Coast, and in numerous other places in the world.

I, therefore, submit that a temperature range of 450 F to 700 F will be encountered in drilling the proposed 50,000-ft well.

CASING AND DRILL PIPE ... **Sheldon Reynolds,** engineer, National Tube Division, U. S. Steel Corporation, Houston, Texas.

Sheldon Reynolds

Mr. Weaver's predicted temperature gets right up to the limit of what can be done with steel, retaining the desired properties. I would not want to go much higher than 700 F with some of the material suggested here.

Drilling a hole to 50,000 ft is going to require some large casing sizes — larger than we have been using so far — which will get out of the realm of materials that have been manufactured to date. I have attempted to vary the size pattern of some of the materials already manufactured and used, at least experimentally.

To start, we propose to use about 2000 ft of 24-in., J-55 casing with a 0.687-in. wall. Collapse failure in this string would be of the elastic type and a better grade would not help. There is no threading on 24-in. casing to date and it would have to be welded. A 22½ in. bit would be run below the 24-in. casing.

Next, down to 10,000 ft with 16-in. OD casing. Existing facilities in some pipe mills would not allow higher than N-80 grade. Wall thickness would have to be 0.843 in. If the casing could be made of P-110 steel, wall thickness could be 0.763 in. which is the lightest wall that could be used to avoid elastic collapse failure. Again, any further increase in strength would be of no benefit.

Through the 16-in. casing, we would drill with a 14⅛-in. bit to 20,900 ft and set 10¾-in. pipe with a wall thickness of 0.650-in. weighing about 71 lb per ft. This pipe would have buttress threads which would develop more than the plain end yield strength of the 150,000 lb per sq in. steel in the pipe. A 9¼-in. bit would be used below this string.

A 7⅝-in. OD, 0.687-in. wall string of 150,000 lb per sq in. minimum yield would then be run as a liner to 36,500 ft with a back-off tool run at 20,700 ft. This pipe would weigh about 51.5 lb per ft and because of its weight would be run on similar casing with buttress threads which would be pulled temporarily above the back-off tool at 20,700 ft to accommodate large drill pipe for drilling to total depth. A 36,500 ft string of 51.5 lb per ft casing would weigh 1,879,750 lb, probably the maximum derrick load.

Final string of casing would be 5 in., run as a liner below the 7⅝-in. liner in a hole drilled with 6⅛-in. bits to 50,000 ft. This casing would be of a grade available today — 150,000 minimum yield — but of 0.434-in. wall thickness with a plain end weight of 21.16 lb per ft.

The upper portion of the drill pipe would be 8000 ft of 5½-in. pipe weighing 24.70 lb per ft and with a yield strength of 135,000 lb per sq in. Drill pipe with this strength is being used experimentally but not yet in this size.

The second portion of pipe would be 13,000 ft of 5½-in. pipe weighing 21.90 lb per ft and with the same yield level. This length represents 1000 ft more than will eventually be needed but will be necessary in drilling the hole for the 10¾-in. casing to 20,900 ft without using a smaller pipe. Following this section would be 2000 ft of 3½-in. drill pipe, 15.50 lb per ft, again with a yield strength of 135,000 lb per sq in. The bottom 28,000 ft would be 3½-in. pipe weighing 13.30 lb per ft. The entire string made up, including the extra 1000 ft of 5½-in. pipe would weigh about 895,000 lb.

Running the 5-in. liner on the drill pipe would add some loading which would not permit using the 135,000 yield strength at the top of the string. To stay within the yield load of the pipe, a strength of 150,000 lb per sq in. would be required. Casing with this strength has been manufactured, but drill pipe is not yet available with this yield strength. However, materials have been used, at least experimentally that would do the job of setting casing at 50,000 ft.

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BAKER

PRODUCTION APPLICATIONS

Baker Retainer Production Packer Product No. 415-D

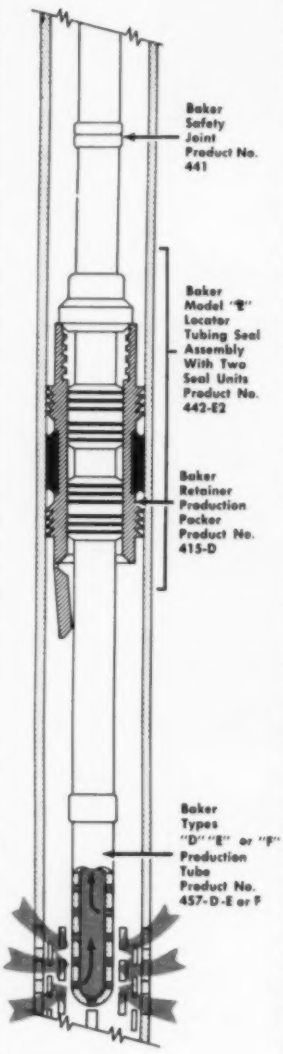
FEATURES

Holds any pressure from either above or below that is safe for the casing, even under temperatures in excess of 300°F.

Pack-off is independent of set-down weight or tension. Tubing string is free; just pick up (or unlatch and pick up) to remove it.

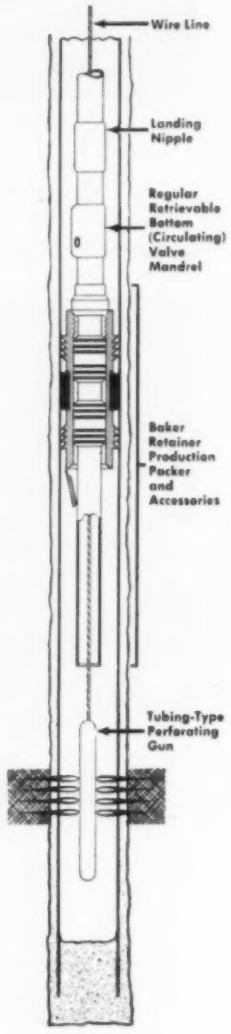
Use it as a squeeze and testing tool or as a temporary or permanent bridge plug in conjunction with any production application.

SINGLE ZONE Normal Completion


Baker Safety Joint Product No. 441
Baker Model "B" Locator Tubing Seal Assembly With Two Seal Units Product No. 442-E2
Baker Retainer Production Packer Product No. 415-D
Baker Types "D" "E" or "F" Production Tube Product No. 457-D-E or F

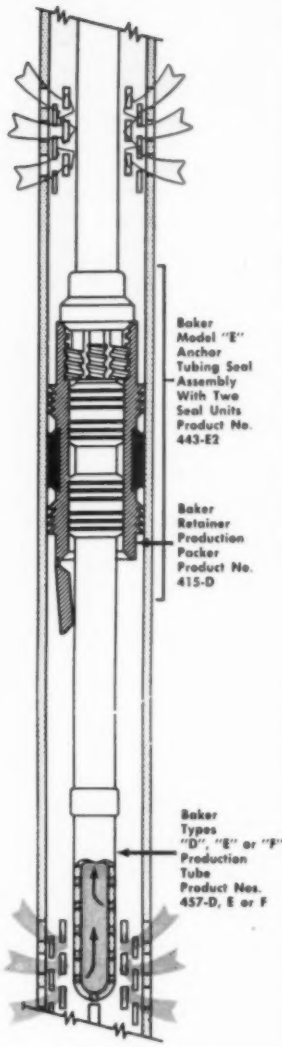
Illustrates Packer set in casing with Locator Tubing Seal Assembly and Production Tube installed for single-zone production.

SINGLE ZONE Permanent Type Well Completions



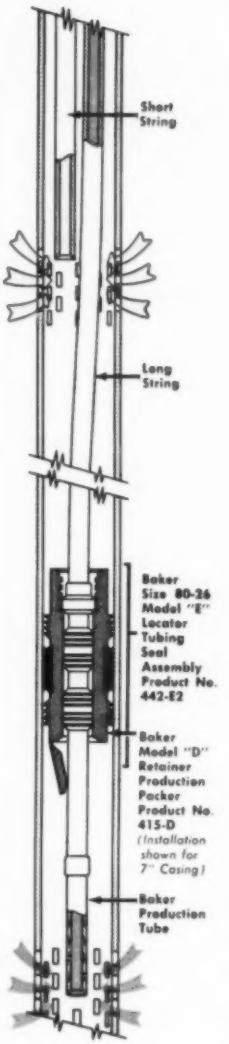
Illustrates typical Permanent-Type Well Completion Hook-Up showing perforating operation through and below the Packer.

DUAL ZONE
Normal Completion


Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Retainer Production Packer Product No. 415-D
Baker Types "D", "E" or "F" Production Tube Product Nos. 457-D, E or F

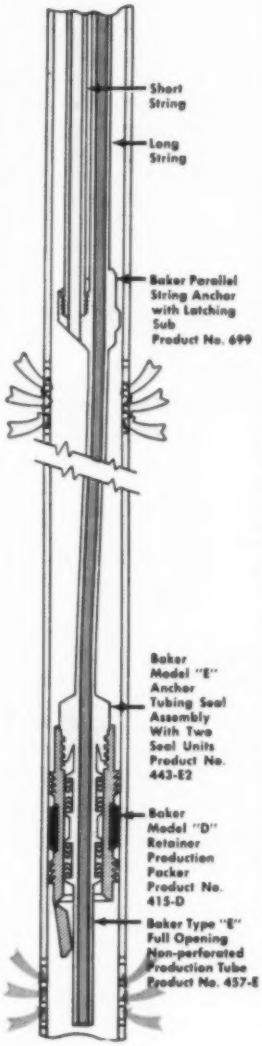
Illustrates Packer set in casing, with anchored production string for dual-zone production. Tubing can be released from Packer by rotating to right.

DUAL ZONE
Parallel String
Short String
Hanging Free


Short String
Long String
Baker Size 80-26 Model "E" Locator Tubing Seal Assembly Product No. 442-E2
Baker Model "D" Retainer Production Packer Product No. 415-D (Installation shown for 7" Casing)
Baker Production Tube

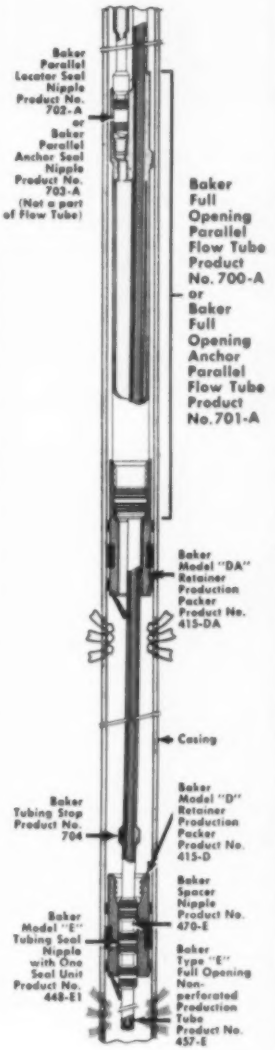
Permits removal of either string independently of the other regardless of sequence. Full-Opening (Tubing I.D.) Long String to lower zone.

DUAL ZONE
Parallel String
Short String
Anchored


Short String
Long String
Baker Parallel String Anchor with Latching Sub Product No. 699
Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Model "D" Retainer Production Packer Product No. 415-D
Baker Type "E" Full Opening Non-perforated Production Tube Product No. 457-E

Permits removal of either string independently of the other, however long string must be run first. Short string pulled first. Full-Opening (Tubing I.D.) Long String.

DUAL ZONE
Parallel String
Two-Packer Hook-up


Baker Parallel Locator Seal Nipple Product No. 702-A or Baker Parallel Anchor Seal Nipple Product No. 703-A (Not a part of Flow Tube)
Baker Full Opening Parallel Flow Tube Product No. 700-A or Baker Full Opening Anchor Parallel Flow Tube Product No. 701-A
Baker Model "DA" Retainer Production Packer Product No. 415-DA
Casing
Baker Tubing Stop Product No. 704
Baker Model "D" Retainer Production Packer Product No. 415-D
Baker Spacer Nipple Product No. 470-E
Baker Model "E" Tubing Seal Nipple with One Seal Unit Product No. 448-E1
Baker Type "E" Full Opening Non-perforated Production Tube Product No. 457-E

Illustrates Two-Packer parallel string installation with each zone confined to its individual tubing string with full-opening to lower zone for use of all permanent-type completion tools.

RIG EQUIPMENT . . . **Jack Abernathy**, vice president, Big Chief Drilling Company, Oklahoma City, Oklahoma.

Jack Abernathy

In considering rig equipment for this 50,000-ft hole, we made certain assumptions which vary somewhat from the hole and casing choices made by Mr. Reynolds. We contemplate setting 25,000 ft of 9⅝-in. casing which would have a dry weight of approximately 1,250,000 lb and a weight in 18-lb mud of approximately 800,000 lb. A 7-in. liner run on drill pipe to 35,000 ft would have a dry weight of about 1,000,000 lb and, if run in 18-lb mud without any floating, would weigh from 650,000 to 700,000 lb. If a 5⅝-in. hole were subsequently drilled to 50,000 ft, the maximum load would come at the time of running the 9⅝-in. casing, roughly 1,250,000 lb of dry weight.

Many of the larger drilling hoists built today are designed for a safe single-line pull in the range of 100,000 lb, which is about the maximum allowable working stress desired on normal size wire lines. There is no doubt that several manufacturers today can produce hoists which with very minor modifications would be satisfactory to carry the loads anticipated.

A 1½-in. wire line of high strength design has a breaking strength of about 114 tons, providing adequate strength for this particular operation.

I think that it is a fair assumption that, with an adequately designed rig, round-trip time from 40,000 ft — or even deeper—will be around 24 hours.

Considering the mud velocities necessary for removing cuttings and the hydraulics of the string of drill pipe, it is my conclusion that the mud pumps must be capable of continuous operation at from 5000 to 6000 psi. Continuous operations in the order of 3000 psi have recently been realized with single stage duplex pumps, although at substantial cost for valves, stuffing boxes, piston heads, etc. There are some other types of multiple cylinder pumps which offer considerable promise of operating satisfactorily at 5000 psi continuous discharge pressure.

I doubt that rotary tables and swivels in their present design are adequate for rotating loads we are considering. They are heavy enough for required static loads and probably the equipment manufacturers can come up with what is needed if given adequate notice.

DRILLING FLUIDS . . . **O. W. Van Dyke**, vice president, Magnet Cove Barium Corporation, Houston, Texas.

O. W. Van Dyke

In considering a mud program for a deep well, much attention must be given to the complications resulting from high temperatures. For the purpose of this discussion, I have assumed that it is desirable to make preparations for dealing with bottom-hole temperatures that will approximate 875 F.

Formation pressures, overburden pressures and hydrostatic pressures exerted by a 50,000-ft column of mud must be considered. If there is such a thing as a normal formation pressure, it would be considered to be 46.5 psi per 100 ft, which at 50,000 ft would be 23,250 psi.

Experience to date indicates that there is a probability that abnormal pressures approaching actual overburden pressure can be expected at extreme depths. If such pressures exist at 50,000 ft, the bottom-hole pressure would be 47,500 psi. In all probability the density of the overburden will increase with depth and it is likely that it will approximate 2.75 at 50,000 ft, which would be equivalent to 59,500 psi.

Minimum weight fluid I would consider practical for such an operation would be 10 lb per gal, which would exert a hydrostatic pressure of 26,000 psi. Maximum weight fluid I would consider an expectancy is 17 lb per gal which would exert a hydrostatic pressure of 44,250 psi.

We currently have drilling fluids that are known to be stable at 500 F and in all probability fluids that are stable under much higher temperatures exist today, but to my knowledge no laboratory work has been done under the conditions of temperature and pressure which are indicated in a 50,000-ft hole.

The principal properties of a drilling fluid such as weight, viscosity, yield point, and fluid loss can be controlled over relatively wide ranges. Filtration properties at extremely high temperatures may be difficult to control, but in all probability the porosity and permeability of the rock at extreme depths will be very low, which would probably be a compensating factor to prevent difficulty due to filter caking.

According to literature, the plastic deformation of minerals is greatly increased by temperature, probably doubling every 10 F rise in temperature. Under the conditions of high temperature and high pressure, certain types of formation rock may be troublesome due to plastic deformation. High mud weights may be required to keep this from becoming a serious problem.

Loss of circulation due to fracturing of the formation may be serious. It can be expected that the formation rock will be more dense and stronger in compression, but it is doubtful that its tensile strength will be increased appreciably. If it becomes necessary to use mud weights approaching the overburden pressure, the added pressure exerted on the formation due to friction in the annulus may become a serious problem. The friction in the annulus can be minimized by controlling the flow properties of the mud so that the yield point is very low.

ELECTRICAL LOGGING ... **W. B. Steward,** assistant to vice president of engineering, Schlumberger Well Surveying Corporation, Houston, Texas.

W. B. Steward

It was expected, before last week, that a 30,000-ft level would last as a design factor for 5 to 10 years at least. However, we've now been alerted for a 50,000-ft well and what can we do?

Our heavy duty field units are presently equipped with 25,000 ft of cable, so we would have to double our cable-carrying capacity. This is, of course, well within engineering know-how.

Our cables, because of the relatively low density of the core, have considerable floating action. We can therefore design self-supporting cables to reach any depth that can be reached by tubing and drill pipe. In fact, our present field cable could be used in a 50,000-ft well so far as strength is concerned.

Unfortunately, the strength of our cables is not the major problem. High temperatures — 450 F to 700 F, as outlined by Mr. Weaver—would completely destroy the insulation of our regular cables. The common insulating material, rubber, loses both its elasticity and the majority of its insulating properties at temperatures slightly under 450 F. However, we have developed a cable whose characteristics appear, on preliminary tests, to be satisfactory to 600 F, but to bridge the gap from 600 F to 700 F may be quite difficult. None of the flexible plastics developed so far are satisfactory as cable insulation above 600 F. However, because of the large amount of work being done on missile programs, it is our hope that material will be developed soon which will enable us to design cables for 700 F.

In the design of down-hole equipment for logging this 50,000-ft well, the major problem will again be the very high temperatures encountered. The problem primarily is one of obtaining material which still behaves as an electrical insulator at these elevated temperatures. Fortunately, for our down-hole equipment the insulating material does not have to be flexible and it is possible there to use ceramics, micas, etc.

For the non-electronic services such as our basic electric log, we could proceed directly to the design of the sonde by applying presently known techniques, with every confidence of success, even anticipating the maximum design requirements for pressure and temperature. For the more modern and specialized logs, requiring electronics down-hole, completely new circuit designs would be required to adapt them to the limited and inefficient components which might become available for such elevated temperatures.

Fortunately, a new series of ceramic vacuum tubes is available which functions satisfactorily up to 900 F, but associated electronic components such as condensers, resistors, transformers, etc., have not kept pace with the tubes. Again, with the heavy governmental emphasis on research and development in both nuclear and missile fields, we would anticipate that suitable components should be available soon.

Once the 50,000-ft well is drilled, let us be optimistic and assume that the electrical logging company was called to perforate the pay zone. Here we can speak with considerable confidence. High temperature propellants for gun perforators have been developed and we have tested them satisfactorily to temperatures in excess of 500 F. For the upper range of bottom-hole temperatures which might be encountered, we would expect to go to special shaped charge explosives. High temperature blasting caps for ignition of the shaped charge have to be developed. But this does not appear to be an insurmountable problem.

I have refrained from commenting on the problems presented by the high pressures anticipated in this 50,000-ft well, not to minimize the importance of high pressure, but because solving the problem of high pressure for one piece of equipment sets the design for most others and it is believed that present engineering know-how is sufficient to design down-hole tools to perform satisfactorily in a pressure range of 30,000 to 50,000 psi.

So it is with confidence that we say, "You drill 'em, we'll log 'em."

DRILLING BITS ... **Lyle Payne,** assistant vice president — engineering, Hughes Tool Company, Houston, Texas.

Lyle Payne

In consideration of drilling bits, there are three factors that would affect the efficiency of the bit. One is the size of the bit. With the casing programs that have been proposed today, we would anticipate that we could go on from approximately 36,000 ft to 50,000 ft with either a 5⅝-in. bit or a 6⅛-in. bit with a fair degree of bit efficiency. However, if we should encounter difficulty and should have to set a liner or another string of casing through which we would operate with a greatly reduced size bit, then it might well be that the rolling cutter type bit would be very ineffective from an economical consideration. It would then resolve into drilling with drag-type action and formations might or might not respond to this type action which is embodied in drag bits and diamond bits.

A more important factor, I believe, will be that of pressure. Based upon laboratory investigations involving drilling under confined pressure, the most drastic reduction in drilling rate occurs at rather low confining pressures — in the order of 1000 to 2000 psi — with some reduction up to 5000 psi, but from 2000 to 5000, the slope of a decrease in penetration rate curve is very flat. We might therefore anticipate that in those rocks such as limes and dolomites of low permeability, we would drill from possibly one-half to two-thirds of the rate that would be drilled at 5000 psi — or around 10,000 ft.

The more permeable rocks such as shales and sandstones could be more adversely affected by pressure, particularly if we experience a considerable pressure drop across the cutting face of the rock. In that case, we would encounter a filter cake build-up in which the cutting teeth of a rolling cutter bit might not reach virgin formation. The only solution would be good jet bit application to minimize the filter cake along with very careful control of mud weight in order to maintain a balance across the cutting face of the rock.

The effect of high temperatures will also give us some very real problems. Present-day rolling cutter bits are made of a high-nickel steel alloy that has the property of having a very tough core which responds to deep carburizing and heat-treatment to produce a file-hard shell surrounding a soft, tough core. At high temperatures, this material will draw back to a soft condition, one that can be filed. The teeth would upset under loads required to drill efficiently if subjected for any sustained period to temperatures above 400 F. Other high alloy materials, such as chrome or tungsten alloys, would not be effective as rolling cutter rock bits because of the brittleness of the core.

I think that refrigeration of the circulating system would be a prerequisite, not only when on bottom, but also during trip time in or out, in order to keep the bit below the draw temperature that would ruin its effectiveness.

CEMENTING ... W. D. Owsley, senior vice president, Halliburton Oil Well Cementing Company, Duncan, Oklahoma.

W. D. Owsley

Not having any doubt whatsoever that someday a 50,000-ft well will be drilled, I think I'd better say that if it's drilled, we will cement it.

There are several manufacturers today who could, in my opinion, produce the auxiliary equipment necessary to the cementing of the casing strings for this well. Pumping equipment is not an insurmountable problem. At this very moment there are some pumps under construction which will be available before very long capable of operating at 20,000 psi. Operating pressures beyond that can be accomplished.

Presently, there is no laboratory equipment in existence capable of simulating the 50,000-ft well depth as to pumpability of cementing slurries or muds. The upper limit at present of such equipment is about 500 F at around 20,000 psi. However, that equipment can be so modified that it will take care of any of the pressures and temperatures mentioned in this discussion today.

Presently existing cements of the portland cement variety cannot be used with any known retarding agents at the temperatures and pressures involved. In addition, retrogression in strength of those materials would be so marked that in a very short period of time you might as well not have them. There are compositions in use which it is believed can be modified to produce a cementatious material capable of pumpability time sufficient for the 50,000-ft well. That is assuming pumpability in the neighborhood of six hours, pumping at around 40 cu ft per min.

The cementing composition which, to my knowledge, has been tested to the highest temperature is a pozzolanic composition which has been tested under simulated well conditions to 500 F, though not to the pressures we are talking about. There are some retarding chemicals to which such a composition reacts very nicely. There are other retarding chemicals which have never been put into a well, but laboratory tests indicate that they could be used up to 1000 F and still produce a set mass of good strength.

The cementing job on this well will be a trying thing, as most deep-well cementing jobs are, but I am confident that if it can be dug, it can be successfully cemented.

OPERATIONS ... Thomas Pennington, Jr., senior supervisor drilling engineer, Humble Oil & Refining Company, Houston, Texas

Thomas Pennington, Jr.

I am speaking in the absence of Mr. J. E. Hill who unfortunately could not be with us today.

I am sure that we, as engineers, all take a certain amount of pride and gratification in the reports of this panel and the very optimistic viewpoint they take toward drilling a 50,000-ft well. Just about 27 years ago, the first 10,000-ft well was drilled, and in 1956 we find that there were over 2600 wells drilled below 10,000 ft. One source has indicated that by 1965, we will be drilling as many as 4000 wells a year deeper than 10,000 ft. Of this number, there would be about 82 wells below 18,000 ft.

As to the earth conditions and the temperatures we might find, it is well to realize that we may expect temperatures up as high as 500 F even in 25,000-ft wells, which certainly means that some of the problems that have been recited here today are facing us right now.

Nothing has been said about pressure seals and pressure control equipment, but we do know that a considerable amount of engineering effort has been expended to develop the drilling tools and techniques which will permit drilling and completing 25,000-ft wells. It is evident from the discussion presented that it is at least theoretically possible to drill a 50,000-ft well. Flange seals have been developed for 15,000 lb per sq in. working pressure, but undoubtedly we will have to control pressures even higher than that.

As to handling the drill pipe, it appears that one of the things we might wish to look at seriously in the future is the development of some type of automatic drill pipe handling equipment and tools which will prevent damage to drill pipe as a means of reducing failures as well as lower the drilling crew fatigue level.

We can see that in this super-deep drilling there is a real challenge for the engineer who specializes in drilling equipment and in drilling methods.

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P 535.2

PLASTIC PATCH SEALS CASING LEAKS

Pan American develops, tests "Casing Patch;" fast application, small ID reduction, high tensile strength among advantages

HOLES IN CASING are being successfully repaired by a new system developed and field tested by Pan American Petroleum Corporation. Called a "casing patch," it is applied to the inside of the casing.

Inexpensive and easy to operate, the casing patch is set in place by applying thermal setting plastic to holes or splits in the casing. The tool for applying this patch has only one principal part — an inexpensive inflatable mandrel, on which is wrapped fabric impregnated with the plastic.

Diameter and length of the mandrel can be varied to fit the size of the casing to be repaired and to cover the area or vertical distance to be treated. Ready for use, the casing patch assembly is composed of the mandrel, wrapped with plastic-impregnated fabric, and equipped with valves and two tubing centralizers.

Application

To repair a leak, this procedure is followed: Fabric strips are cut to the proper length and width to cover the mandrel. Catalyzed plastic is spread on the pre-cut fabric strips, and these are wrapped on the mandrel. The number of strips used is determined by the size of the hole or split to be patched. The area in the well to be patched is brushed by a wire scratcher.

After attaching tubing centralizers to each end of the mandrel, the device (in one type application) is connected to the tubing and lowered into the hole to the proper depth. Water or oil is pumped down the tubing string, inflating the mandrel securely against the sides of the casing, forcing excess plastic through splits or holes, and forming a seal. Under differential pressure, the plastic is squeezed through holes or splits and "rivets" itself to the casing. Inside the casing, a smooth sheet of reinforced plastic coats the walls. The assembly is left in place 12 to 24 hours, during which time the plastic becomes extremely hard. Mandrel is then deflated and removed from the well, and repair is completed.

Little ID Reduction

Of importance to production men is the fact that the patch can permanently seal holes and splits in casing without seriously reducing the effective inside diameter of the casing. A typical patch reduces the inside diameter of casing by about 6/10 of an inch. This means equipment such as packers, clean out tools, additional casing patch assemblies, and other equipment will not be obstructed by the patch.

The casing patch can be prepared for running into the well in less than 30 minutes by experienced crewmen. Although Pan American personnel have lowered the assembly into wells on tubing in experimental field tests, it could be adapted to wire line tools.

Potential application of the casing patch is great. It can replace cement squeeze jobs to seal perforations; it is possible to adapt it for use in open-hole operations to isolate short sections of formation, eliminating the use of expensive casing.

In well remedial operations, in addition to sealing casing leaks, it can be used to seal off highly permeable streaks in open hole to control production or injection of well fluids.

Strength

Pressure tests on a typical casing patch show effective sealing of holes up to ¼ inch in diameter at external pressures of 8000 psi. A sample of the patch material had a tensile strength of 48,000 psi.

The casing patch has been run in five wells in different parts of the country. It was successful in three wells where leaks were of the type anticipated. The patch was not successful in one well where casing was parted and in another where it was later learned that there was a split two inches wide and four feet long.

Pan American is currently negotiating licensing agreements with a number of oil field service organizations.

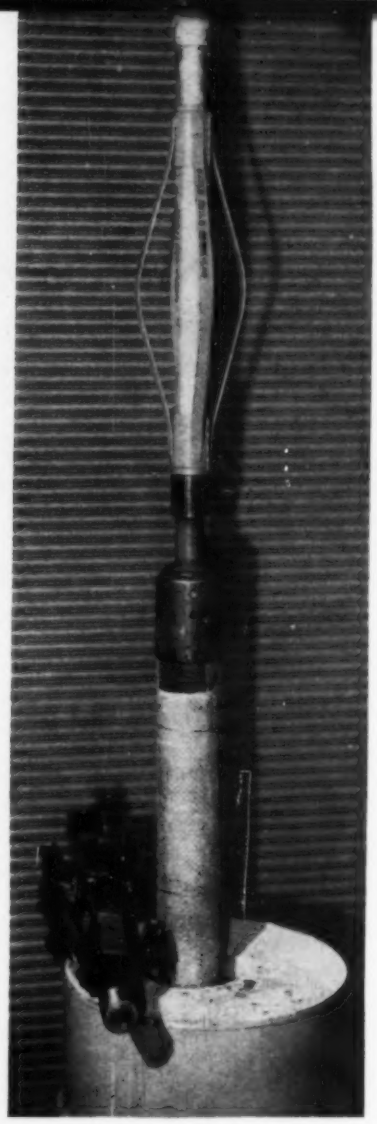


FIG. 1. **Running the tool.** Tubing centralizers are fitted at each end of the special inflatable mandrel. It is then attached to tubing and lowered into the hole to the interval to be repaired. (Casing scratcher, left, lying on top of simulated well, is run in first to brush the casing.) Mandrel is then inflated against walls of the casing by applying pressure to the tubing. The plastic flows through splits or holes, riveting itself to the outside of the casing and coating the casing inside. After 12 to 24 hours, mandrel is deflated and removed from well.

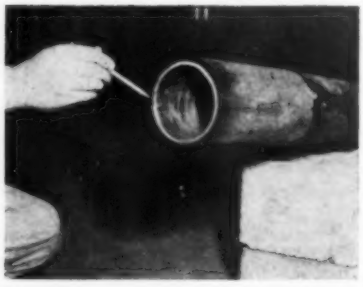
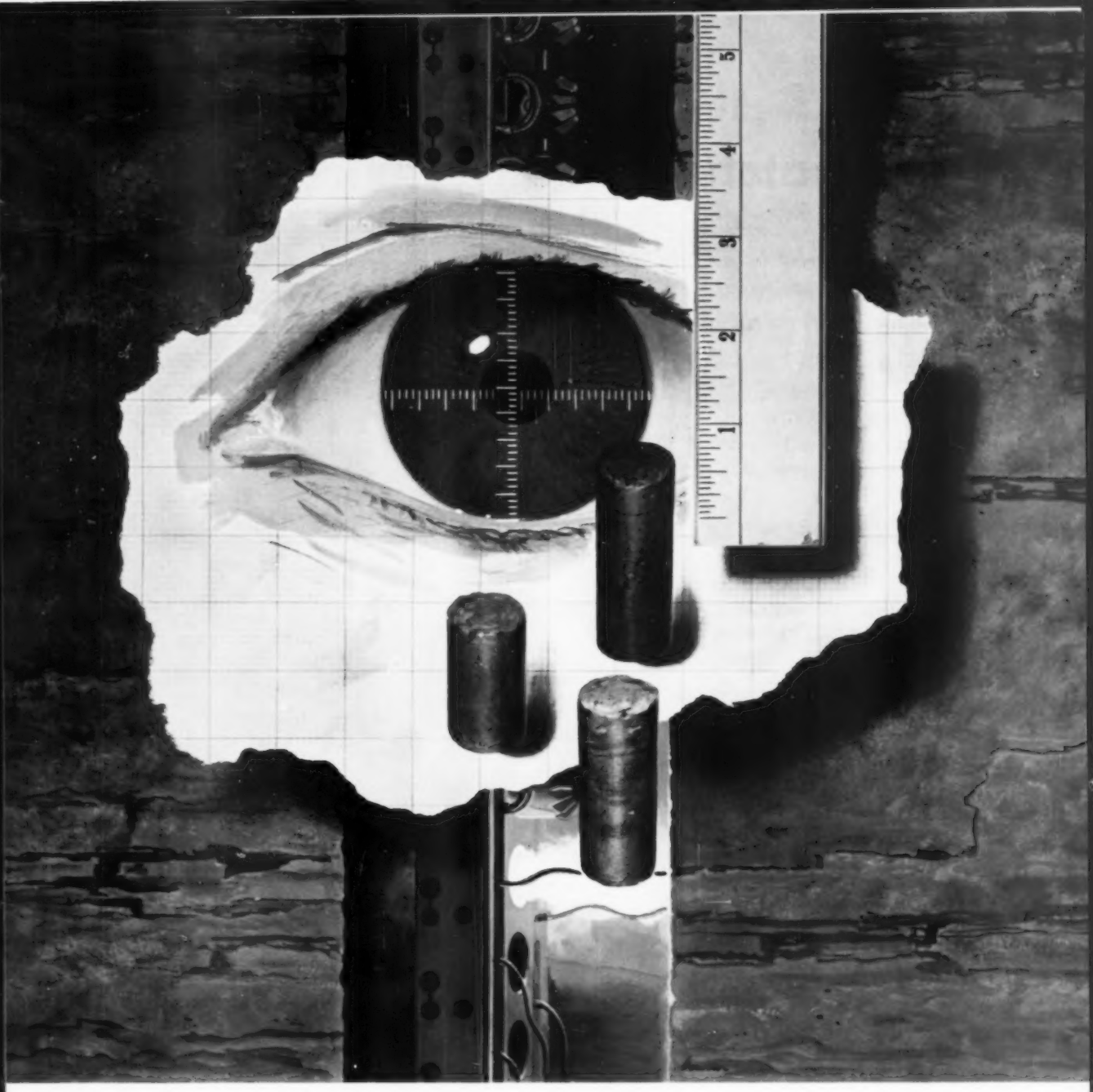


FIG. 2. **Cross section of the patch** inside casing illustrates the plastic seal. Average application reduces the inside diameter of the casing about 6/10 of an inch.



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Ask your Schlumberger representative to advise you how Schlumberger Side-Wall Cores can help reduce costs, and give a better, faster look at production possibilities.

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SCHLUMBERGER

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Selection, design, and use of tubing for

COMPLETING HIGH-PRESSURE WELLS

Most tubing failure can be traced to user abuse and design miscalculations. Upgraded manufacturer specifications, proper design and field handling are fast reducing tubing trouble in high-pressure wells

M. J. Epperson
Tidewater Oil Company
Houston, Texas

AS THE RESULT OF deeper drilling, many abnormally high-pressure reservoirs have been discovered in the past several years. Numerous completions have been made where shut-in surface pressures exceed 5000 psi. Some have been made with surface pressures in excess of 10,000 psi. Of the equipment used in completing these wells, the most critical item is tubular goods. Practically all failures of completed wells can be attributed to the failure of tubing or casing. Failures of wellhead equipment, valves, and related items from causes other than corrosion are rare. When the conditions under which the tubular goods are expected to perform and the quality of tubular goods now available are recognized, it can only be concluded that perhaps not enough attention has been given to this subject.

In the selection of equipment to complete high-pressure wells, which for the purpose of this discussion will be defined as those with surface pressures of 5000 psi or higher, the operator must meet two basic requirements. These requirements are: (1) To provide equipment capable of containing the maximum pressures to be encountered, and (2) to provide some means of corrosion control to insure that this equipment will remain capable of containing the pressures as long as it is required to do so. These are basic requirements for any well, but are of major significance in the deeper, higher-pressure wells because of the higher cost of drilling and completing, the corrosive nature of the produced fluids, and the high potential loss that may result in the event of a failure.

There are several factors involved in the selection, design, and use of tubular goods necessary to meet these requirements. The conditions under which the tubular goods are expected to perform and the methods which are being, or can be, used by the operator to obtain satisfactory performance must be considered. In general, no minimum standards as to design or use are proposed. This must be determined by the individual operator and may depend upon many other factors.

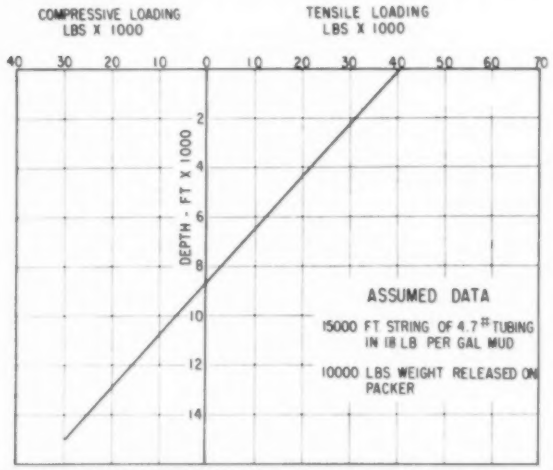
This paper presented at the Spring Meeting of the Southern District, Division of Production, American Petroleum Institute in Houston, Texas, February 26-28, 1958.

SELECTION OF TUBULAR GOODS TO CONTAIN PRESSURE

Tubing

1. Function of, and Forces on, Tubing String.

The tubing string can be defined as the primary pressure containing string. It is the string that contains well pressures and through which the well is normally produced. Although a number of papers have been written on problems related to the design and use of casing strings,[1-8] very little has been published concerning tubing strings. This string taken as a unit, is probably the most critical single item of the completed high-pressure well. It is subjected to almost every conceivable type of force and is generally more highly stressed than any other equipment. The major forces acting on this string from top to bottom are indicated in Fig. 1 and 2. Fig. 1 indicates ten-



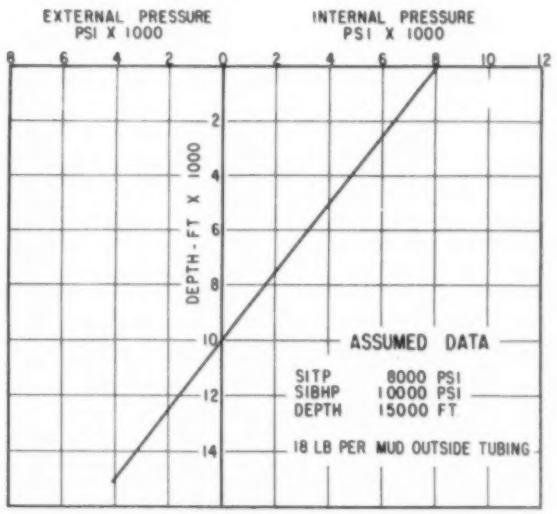


Fig. 1. and Fig. 2. Loading, or stress, from the top to the bottom of a typical tubing string. Lack of stress on the bottom two-thirds of the string indicate that most of the benefits of field inspection could be obtained by inspection of the top section only.

sile and compressive loading of a typical string. Internal and external-pressure loading is indicated in Fig. 2. Not only do these forces vary from top to bottom of the string, but because of changes in temperature and pressure as the well is alternately shut in and produced, they may also vary in degree.

2. Ideal vs Actual Tubing String.

The ideal string would be one in which each length of tubing was made of homogeneous material of uniform physical properties, completely free of defects, and with end connections that would provide a leak-proof seal when made up under field conditions.

The actual string, which for a 15,000-ft well would consist of approximately 500 individual lengths of tubing, varies considerably from this. Wide variations in physical properties sometimes exist from length to length, or even within a single length. Mill defects, such as seams, plug scores, inclusions and pits, are commonly found in the pipe. Other defects, nicks and cuts, can originate in the field. End connections do not always seal — either as a result of manufacturing defects or, more commonly, improper field handling.

Inasmuch as it is this string that the operator must depend upon to contain well pressures up to and exceeding 10,000 psi, the possibility of tubing failure must always be recognized. This possibility can be reduced but can never be completely eliminated.

3. Reducing the Possibility of Failure.

With the conditions under which the tubing string is expected to perform, the quality of the material, and damage resulting from field handling in mind, methods of reducing the possibility of failure will be reviewed.

a. *Field handling.* This would include any damage to tubing or connections while in transit, picking up, stabbing, tonging, and running. Also, because the tubing may be run more than once, pulling, breaking out, and laying down should also be included. Sources of damage during these operations are numerous[12] and may result in failure of the connection to seal or in the pipe itself failing. Fortunately, most failures resulting from improper handling can be prevented by proper supervision and by the use of trained personnel. Realization of this has resulted in a sharp reduction in the number of failures from this cause in recent years. However, this factor is still important.

b. *Testing and inspection.* It requires only a scant knowledge of the many metallurgical and production problems involved in the making of steel and the manufacture of tubular goods to realize that it would be an exception, instead of a rule, to obtain a string of tubing without some mill defects. Failures resulting from defective material have received the most publicity recently. Whether this results from the number of failures being greater than from other causes or whether it is because several of these failures have occurred in very high-pressure wells is not known. Regardless of the reason, practically all operators have become aware of the possibility, some would say probability, of running defective tubing in their wells. To reduce this possibility many operators have, in critical wells, resorted to additional testing and inspection prior to running the tubing.

High-strength tubing, as it comes from the mill, has generally been hydrostatically tested to 80 percent of its nominal minimum yield pressure and the external surfaces of the tubing have been visually inspected. Tubing with serious defects can and occasionally does get by without being detected.

Field testing usually consists of applying internal hydrostatic pressure up to 80 percent nominal minimum yield pressure either on the racks or when the tubing is being run in the well. Testing the tubing while running is usually perferable inasmuch as each length can be tested under the approximate tensile loading conditions that will exist in the well. Testing at this time also permits the made-up connection to be tested and can be used to reduce the possibility of failures caused by improper field handling discussed previously. Because of the time required to test the entire length of the tubing when running, some operators test only the connection and a short distance on each side of the connection.

Repeating the same test in the field as was applied at the mill may, to some, seem questionable. There have, however, been a number of instances where tubing, supposedly tested to 10,000 psi at the mill, has failed at pressures of 5000 psi or lower in the field. The occurrence of these failures, either while testing or in service, at lower pressures than that at which the tubing had previously been tested at the mill, leaves little doubt that hydrostatic testing, although valuable, cannot be depended upon to eliminate all defective pipe.

More critical inspections can and are being used to supplement hydrostatic testing. Inspections used for tubing include magnetic particle inspection, visual inspection with a borescope, and ultrasonic inspection.

With magnetic particle inspection the pipe is magnetized and sprinkled with iron filings. Defects that come to the surface result in discontinuities in the magnetic field and these defects are detected by the resultant buildup of iron filings. This method is very effective in locating surface defects, but the extent or depth of the defect must be determined by grinding or similar means. Because of the difficulty in applying the iron filings to the inside surfaces of long tubes, in detecting the buildup and determining the extent if defects exist, this method is generally limited to the external surfaces only.

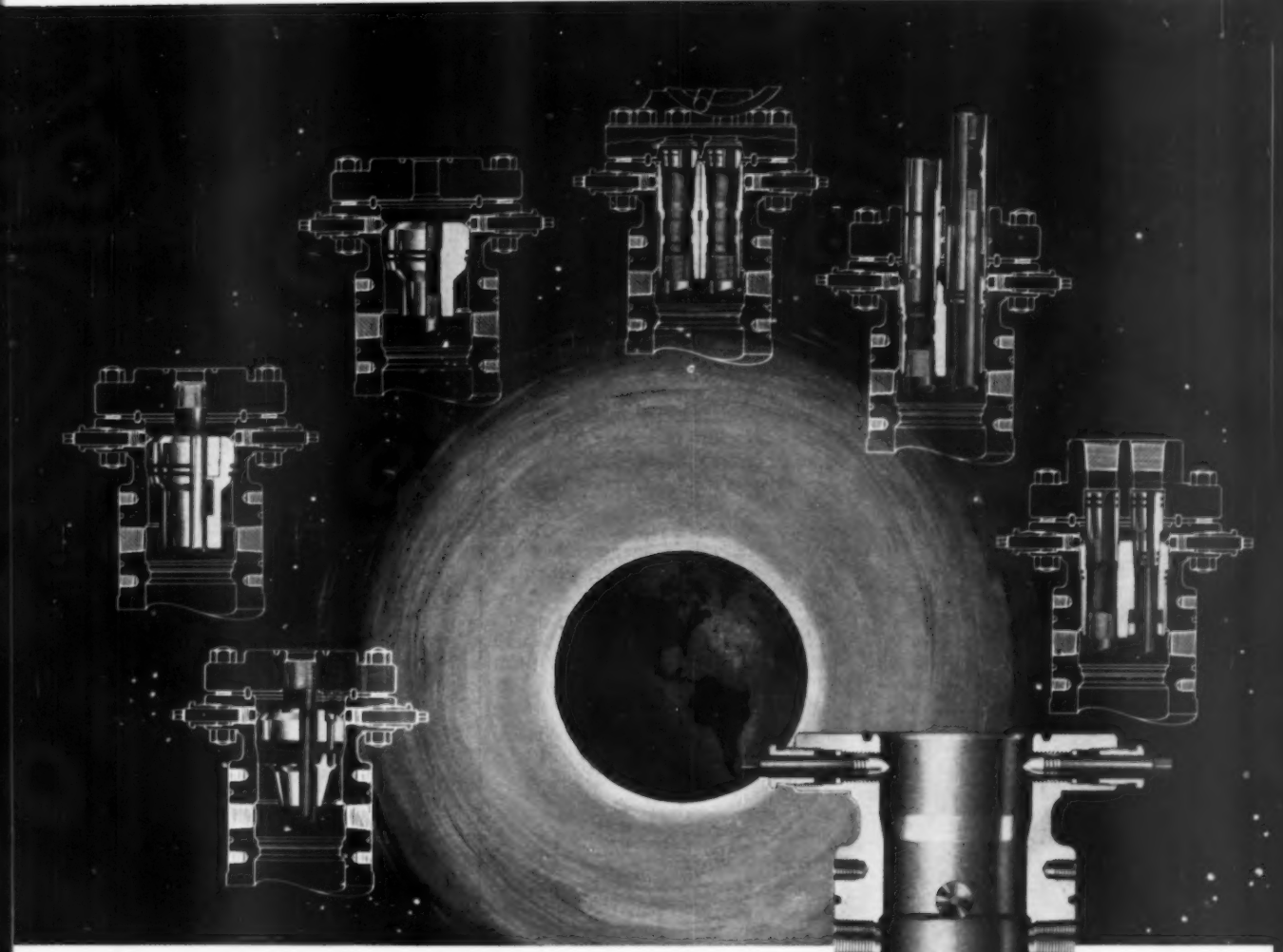
Inspection of internal surfaces usually consists of visual inspection with a borescope. The borescope, consisting of light source, lens, and mirrors, is pushed slowly through the tubing as the inspector observes the inside surfaces. Although this method is capable of detecting many surface defects in the bore of the tubing, its effectiveness is greatly dependent upon the inspector, and it is generally impossible to determine the extent or seriousness of any defects found.

A method which has only recently been adapted to tubing is ultrasonic inspection. This method utilizes high-frequency sound waves which are sent through the pipe body. Discontinuities within the material result in reflecting or deflecting part of the waves. The location and, to some degree, the extent of the defect can thus be determined.

This method has the advantage of being capable of detecting defects that do not come to the surface. Its sensitivity can be adjusted to pick up almost any size discontinuity within the material. Recorders may also be used in conjunction with the pick-up unit to obtain a record of the inspection. This could, to a large extent, reduce the human element so prevalent in other inspection methods. The use of ultrasonic inspection has been rather limited to date and has been used primarily to inspect the end areas of upset tubing for transverse cracks. Interpretation of results obtained and the time required to inspect entire lengths of tubing are major factors in the limited use of this method at this time.

Although all of the methods of inspection have been effective in eliminating many mill defects, it is always possible, either because of the human element or the existence of undetectable defects, such as localized hard spots, that some defective tubing will still get by. Therefore, inspection, the same as hydrostatic testing, can only reduce, not eliminate, the possibility of failure.

The amount of inspection done in the field varies considerably with some operators inspecting most, if not all, high-strength tubing and other inspecting none or only that to be used in extremely high-pressure wells. When comparing the cost of complete inspections in the field to the cost of failure, inspection of all tubing could probably be justified. However, the



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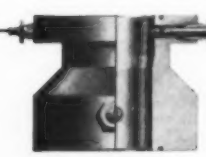

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cost of this inspection is not so easily justified when, in addition to the cost of failure, the probability of such failure occurring with un-inspected tubing and the possibility of failure with inspected tubing are also considered.

Most operators are interested in spending the inspection dollar where it will do the most good. Many limit field inspection to those strings in deep, extremely high-pressure wells. Usually the entire tubing string is inspected.

A more logical approach may be to base field inspection on the stress level at which the tubing is expected to perform. Fig. 1 and 2 indicate the loading, or stress, from the top to the bottom of a typical tubing string. Even if this string was 2⅜ in. 4.7 lb N-80, the bottom two-thirds of this string would be stressed to less than 50 percent of its yield strength because of either tensile loading or internal pressure. This, and the fact that most failures occur in the top section, indicate that for tubing, most of the benefits of field inspection would be obtained by inspection of the top section only.

To further increase the effectiveness of inspection, some operators have set up inspection standards designed to eliminate all except the very shallowest defects. At least one operator has set the maximum permissible depth of external defects at 5 percent of the tabulated minimum wall thickness and requires all defects between 5 percent and 12½ percent of the wall thickness in depth to be removed by grinding.

c. Selection of design factors. Realistic selection of design factors can further reduce the possibility of tubing failures. There are, admittedly, few instances where tubing strings have failed because of being loaded, either in tension or by external pressure, to above their calculated minimum yield strength, much less their ultimate strength. Most failures occur where the forces acting on the tubing are considerably lower than those that should be required to produce failure.

It is apparent that factors other than maximum-tensile and internal-pressure loadings must be considered in the selection of design factors. Consideration should be given to the type, as well as the magnitude of loading. If a well is to be shut in periodically, higher design factors should be used than if the well is to be left open. Defects originating either at the mill or in the field, while possibly not serious under static loading, could result in failure under the cyclic loading conditions that occur as the well is alternately shut in and produced.

The depth or extent, as well as the presence of defects, is also a factor in the selection of design factors. Defects up to 12½ percent of the tabulated nominal wall thickness are permitted by present API specifications.[9] Furthermore, a defect of this depth can, under these specifications, exist in conjunction with minimum wall, which can also be 12½ percent less than nominal. This results in an actual permissible minimum wall thickness, to the bottom of defects, of 75 percent of the nominal wall. Design factors based on minimum yield pressures tabulated in API 5C2,[10] which allows only for minimum wall, would therefore indicate a higher degree of safety than may actually exist.

Degree of safety existing with a specific design factor can be highly dependent upon the depth of defects. As stated before, some operators have set up inspection standards to eliminate all except the shallowest defects. A design factor on tubing containing no defects greater than 5 percent of the wall thickness in depth may be equivalent to a much larger design factor on tubing that contains defects approaching 12½ percent of the wall thickness in depth.

Casing (Oil String)

1. Function of, and Forces on, Oil String.

Because, as has been discussed, the operator can reduce but not necessarily eliminate the possibility of tubing failure, it is necessary to provide some other method of control. The oil string serves as the secondary-pressure containing string. It should, in the event of a tubing failure, provide control until the well can be killed and the tubing string repaired or replaced. The oil string can be defined as that string which is set and cemented into or through the producing formation and extends to the surface. It may be made up of a single size of casing or, in the case of liner setting, two or more sizes of casing connected by cement or other means.

As stated before, a number of papers have been written on the subject of casing-string design and use. In most of the papers published on this subject, the internal pressure is assumed to be normal and pressure requirements are not discussed in detail. For the majority of normal-pressure wells, casing strings designed for tensile and collapse conditions provide an adequate, if not high, design factor for internal pressure. For abnormal-pressure wells, the reverse may be true, i.e., strings designed for internal pressure may provide high design factors in tension and collapse.

To design an oil string it is, of course, necessary to know the magnitude of the forces which may be applied to the string. High-pressure wells are, almost without exception, completed with tubing set with a packer and mud left in the annulus. The maximum internal-pressure gradient which may be applied to the oil string is the pressure gradient resulting from shut-in surface pressure acting on top of the fluid in the annulus. This is indicated in Fig. 3 where the following conditions have been assumed:

Depth of well	14,000 ft
Weight of fluid in annulus	18 lb per gal
Weight of fluid behind casing	18 lb per gal
Oil string	7 in. 26 lb P-110
Shut-in surface press.	8000 psi
Shut-in bottom-hole press.	10,000 psi

Line A represents the shut-in gas

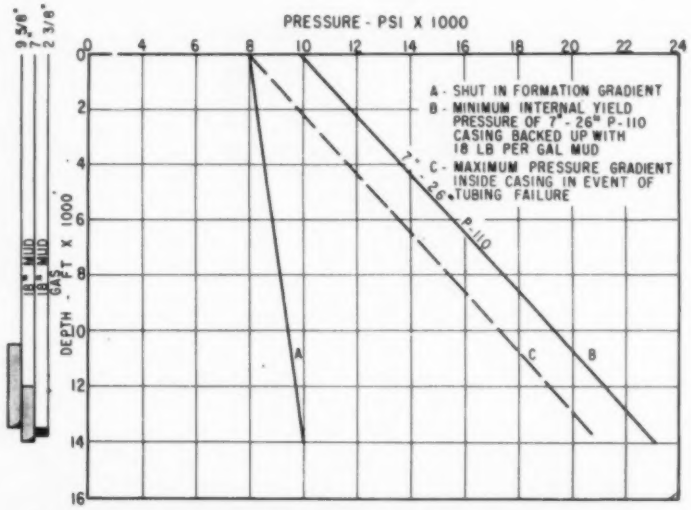

Fig. 3. **Pressure gradient** resulting from shut-in surface pressure acting on top of the fluid in the annulus is the maximum internal-pressure gradient that may be applied to an oil string.

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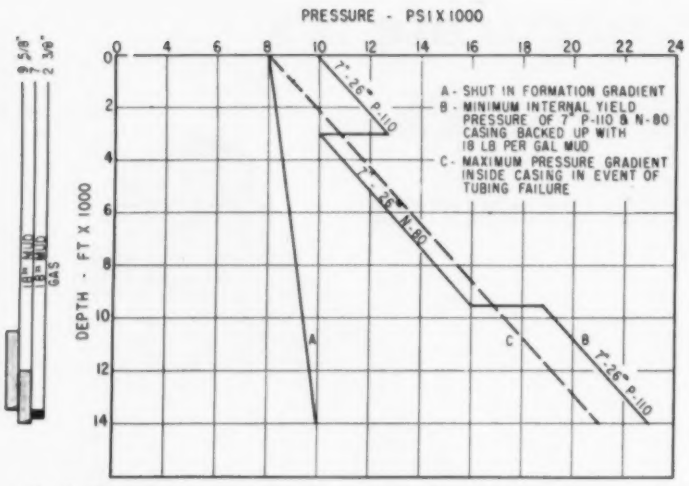

PRESSURE - PSI X 1000
DEPTH - FT X 1000
A - SHUT IN FORMATION GRADIENT
B - MINIMUM INTERNAL YIELD PRESSURE OF 7" P-110 & N-80 CASING BACKED UP WITH 18 LB PER GAL MUD
C - MAXIMUM PRESSURE GRADIENT INSIDE CASING IN EVENT OF TUBING FAILURE
7" - 26# P-110
7" - 26# N-80
9 5/8"
7"
2 3/8"
13# MUD
18# MUD
GAS

Fig. 4. This graph points out the fallacy of designing oil strings on the assumption that internal-pressure differential need be considered only for the top section. It is apparent that maximum pressure gradient resulting from surface pressure acting on top of the mud in the annulus would increase stress the N-80 casing, which forms the center section, above its minimum yield strength.

gradient of 8000 psi at the surface and 10,000 psi at total depth. Line B represents the minimum internal yield pressure of 7 in. 26 lb P-110 casing when backed up with 18 lb mud. Line C indicates the pressure gradient that would occur within the 7-in. casing in the event the tubing string failed and well pressures were applied on top of the mud in the annulus. In this case, the oil string is subjected to uniform internal pressure over its entire length.

From this example, it should be apparent that the differential pressure across the entire length of the oil string must be considered. This is particularly true for combination strings, i.e., those made up of two or more grades or weights of casing. The fallacy of designing oil strings on the assumption that the internal-pressure differential need be considered only for the top section or that only the maximum pressure gradient of the produced fluid need be considered is illustrated more clearly in Fig. 4.

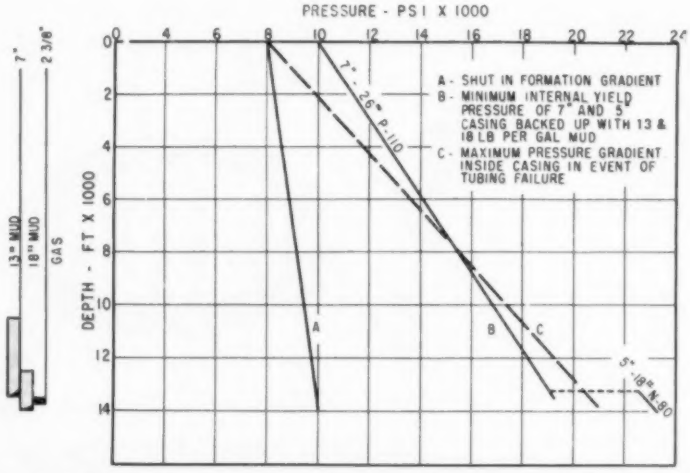
The same conditions are assumed as in Fig. 3 except 7 in. 26 lb N-80 casing is used in the center section. This weight and grade satisfies collapse and tensile requirements. Again Line A indicates shut-in formation gradient, B indicates minimum yield of pipe backed up with 18 lb mud, and C indicates the maximum pressure gradient inside the oil string. It is apparent from the graph that the maximum pressure gradient resulting from surface pressure acting on top of the mud in the annulus would stress the section of N-80 casing above its minimum yield strength.

It should not be inferred from the above example that combination strings cannot be used in deep high-pressure wells. They can and are being used to advantage in many of these wells. In some of the deeper wells, this is almost a necessity in order to meet other requirements, such as tensile loading. When such strings are used, it is essential that the differential pressure across each section be determined. This point was brought out by Texter.[7] He implied, however, that this factor was important only when there is no fluid surrounding the casing.

In both these examples, it is assumed that the mud weight on the inside and outside of the oil string is the same. This condition may not always exist. In many instances, it is not possible to drill into high-pressure formations without first setting an intermediate string of casing right above the zone to be produced. This is because the upper normal-pressure formations cannot withstand the heavy mud weights required to balance the lower high-pressure zone. To avoid the high cost of setting two strings of casing within a few hundred feet of each other, liner completions are sometimes used. In this case, the oil string would consist of two sizes of casing connected by cement. This design can result in a substantial reduction in the initial cost of the well. Although other savings can be effected, the primary saving is in the tonnage and cost of tubular goods. When this design is used, the effect of drilling through the string that may later be required to contain pressure is a factor and is usually considered.

Another factor, which may be even more important is the effect of heavier mud inside the oil string than outside. This is illustrated in Fig. 5. The well conditions are the same as assumed before. However, it is assumed that instead of the 9⅝-in. string, the 7-in. 26 lb P-110 casing is used as an intermediate string and is set at 13,500 ft in 13 lb mud. A short section of 5-in. 18 lb N-80 liner is then set inside the 7-in. string to 14,000 ft, where 18 lb mud is required to hold the formation pressures.

In this case, Line B indicates the internal minimum yield pressure of the 7-in. section backed up with 13 lb mud and 5-in. section backed up with 18 lb mud. Actually the liner would very likely be cemented throughout its length, but for practical purposes the 18-lb pressure gradient can be used. Line C indicates, as before, the internal-pressure gradient if surface pressure is applied to the top of the mud column inside the pipe. It is apparent


PRESSURE - PSI X 1000
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B - MINIMUM INTERNAL YIELD PRESSURE OF 7" AND 5" CASING BACKED UP WITH 13 & 18 LB PER GAL MUD
C - MAXIMUM PRESSURE GRADIENT INSIDE CASING IN EVENT OF TUBING FAILURE
7" - 26# P-110
5" - 18# N-80
7"
2 3/8"
13# MUD
18# MUD
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Fig. 5. Effect of heavier mud inside the oil string than on the outside is illustrated here. Minimum yield strength of the 7-in. casing is exceeded at about 8000 ft.

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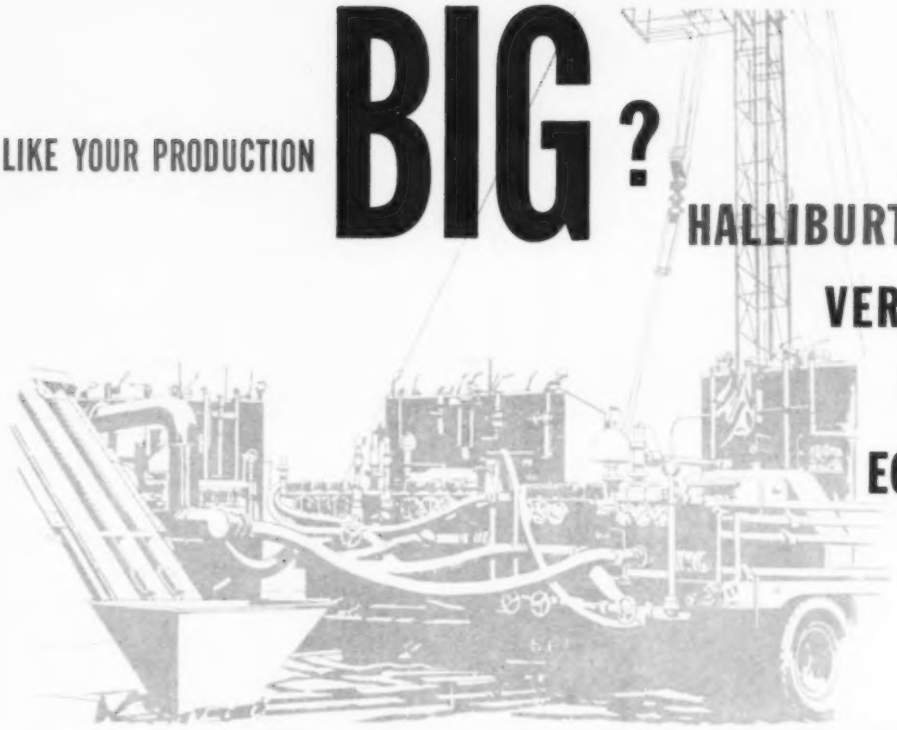

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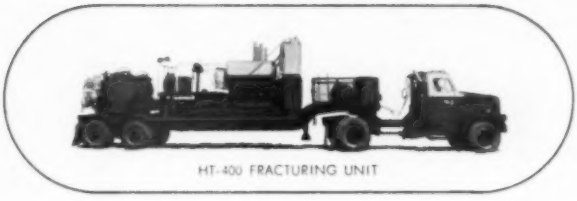

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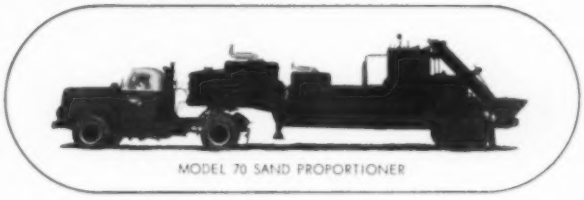

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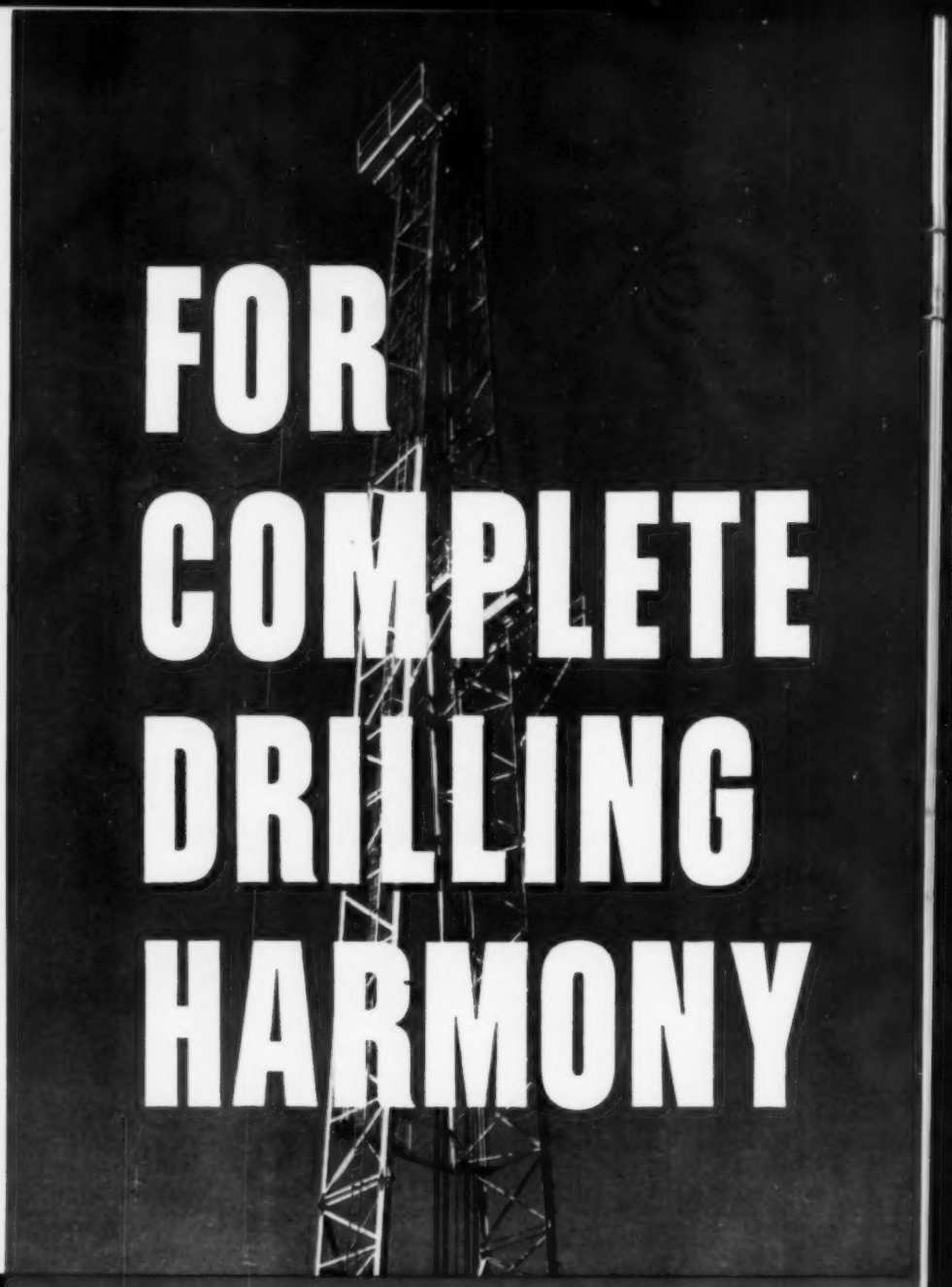

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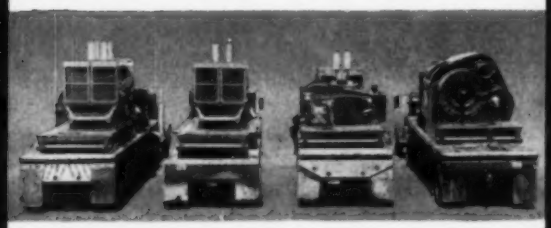

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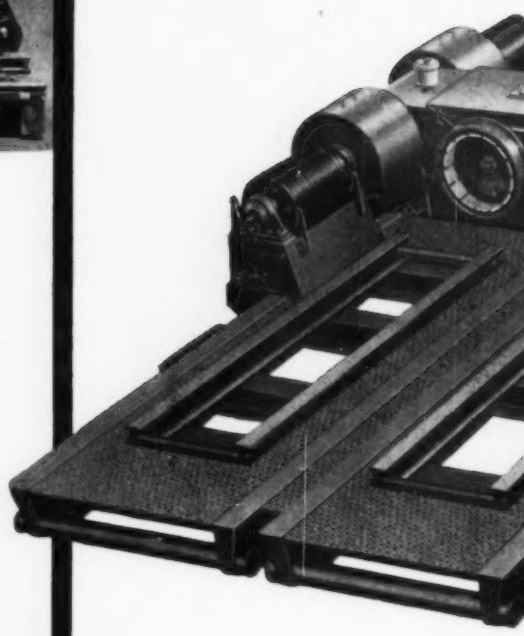

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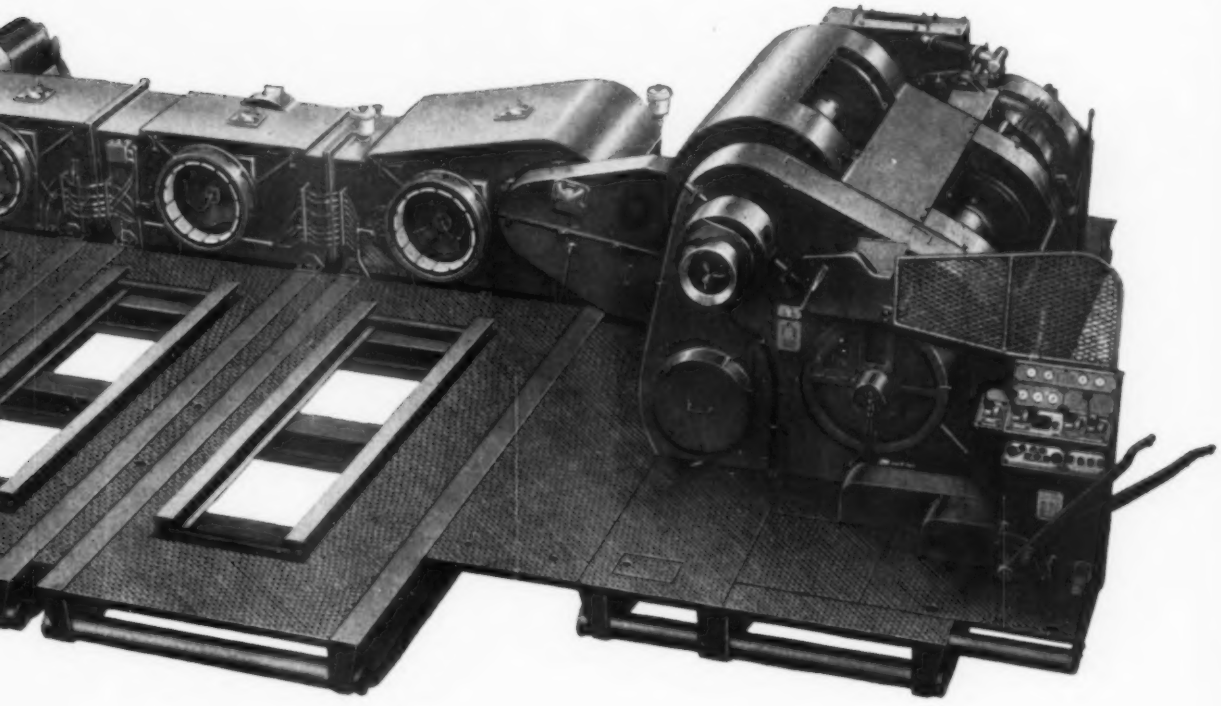

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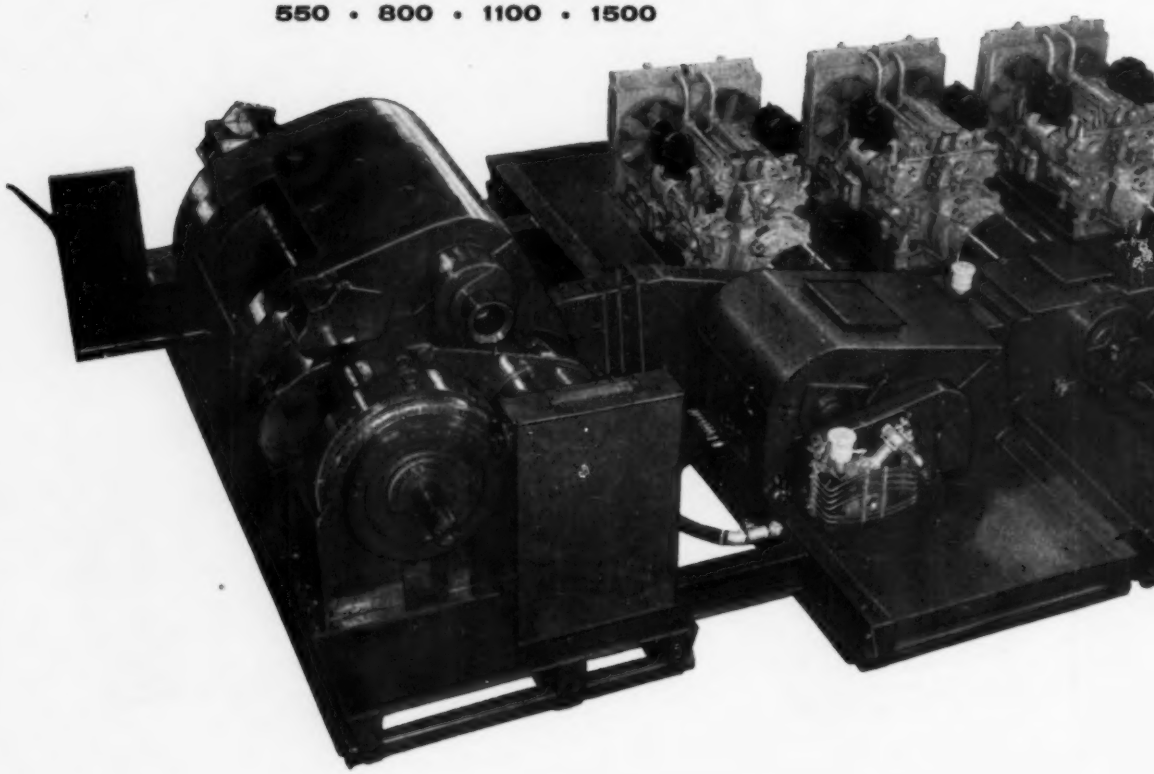

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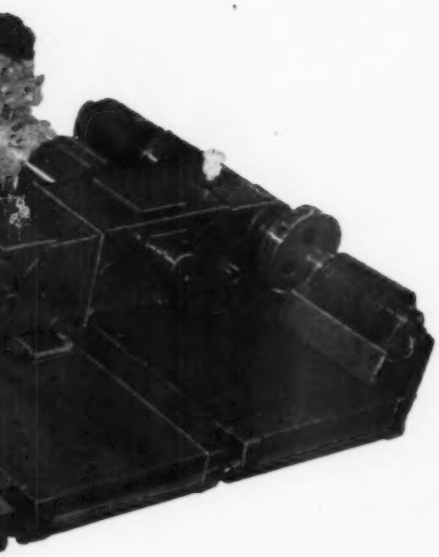

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from Fig. 5 that the minimum yield strength of the 7-in. casing would be exceeded at approximately 8000 ft and that pipe with a higher internal yield pressure than that of the 26 lb P-110 casing would be required to safely complete this well.

Differences in the mud weight inside and outside the oil string may possibly occur although the weights are the same when the well is initially completed. Where the mud column outside the casing is exposed to open formation, this column may drop as part of the mud drains into the lower-pressure upper formations. Settling or dropping out of weighting material within the mud may also possibly occur. These factors could result in the gradient of the mud behind the oil string being less than indicated in Fig. 3 through 5.

As stated by Hills,[2] the external-pressure gradient could, where the external fluid was exposed to open formation, become equivalent to that of the formations. The exposed formations would be normal pressure, approximately 0.435 psi per ft. Therefore, basing the design on the gradient of the mud in which the casing was set may not always result in a safe design. However, this is a step in the right direction and is probably justified until additional work is done to determine whether, and to what extent, the mud gradient outside the casing may change.

2. Effect of Internal Pressure on Other Factors

Existence of internal pressures can affect other factors. Two such factors are the selection of design factors in tension and the casing-landing practice. The Southwestern District Study Committee on Casing Landing Practices[6] of the API recognized this by considering as special cases those wells where heavy mud is used and abnormal pressures are encountered. The committee recommended that where these conditions existed landing practices be determined as set out by Lubinski.[8] Lubinski's paper is primarily concerned with the influence of tension and compression on buckling.

One conclusion reached by Lubinski was that if the mud weight inside the free length of a cemented string of casing is appreciably heavier than that outside, the freeze point must be subjected to some tension to prevent buckling. The amount of tension is proportional to the free length and may be quite large.

Although there is a possibility of the casing buckling under these conditions, increasing the tensile loading after cementing should be approached with caution. Additional tensile loading should be applied only after it and the effect of high internal pressures tending to increase the tensile loading have been considered.

Some idea of the increase in tensile loading caused by internal pressure can be obtained by considering the first example shown in Fig. 3. In the event of a tubing failure, the pressure inside the casing would be increased uniformly from top to bottom by 8000 psi. The resulting increase in tensile loading at the top of the string can be determined by the following formula described by DeHetre.[4]

$$P = 0.0434 \times W \times p \times \frac{D}{t}$$

Wherein:

P = change in loading at the surface, lb,

W = nominal weight of casing, lb per ft,

p = change in pressure, psi,

$\frac{D}{t}$ = ratio of diameter to wall thickness.

The increase in tensile loading at the top of the string would in this case be $P = 0.0434 \times 26 \times 8000 \times 19.337$, or 175,000 lb. This is approximately 29 percent of the minimum pull-out strength of 7-in. 26-lb P-110 casing.

In the example described in Fig. 5, the additional tensile loading would be somewhat greater. The tensile load at the surface would be increased by 29,000 lb just by changing the mud weight inside the string from 13 lb to 18 lb (assuming that this string is free to the top of the cement at 10,500 ft).

Design factors in tension are usually relatively high as indicated by the survey made by an API Mid-Continent District Study Committee.[6] It is therefore unlikely that the additional tensile loads that may be applied either intentionally to prevent buckling or by pressure increases within the string would result in the string actually parting. These factors should, however, be considered by the operator in order to determine the true design factors.

Another factor that may be mentioned is the effect of tension on the ability of connections to contain pressure. Some references[3, 11] indicate that the API threaded and coupled connection may be expected to leak when highly stressed in tension. Tests conducted by Thomas and Bartok[3] indicated that leakage may occur as the applied tensile load approaches or exceeds that load required to produce yielding at the last engaged thread of the connection. Holmquist, in his discussion of the Thomas and Bartok paper, reported similar results. All of the tests, however, were conducted with relatively low internal pressures.

The question of whether the same results would be obtained if higher internal pressures were applied in conjunction with the high tensile loading, as asked by Clinedinst in his discussion of the Thomas and Bartok paper, has not, to the knowledge of the writer, been answered to date. Further investigation of this subject is warranted. With present design factors used for oil strings, the connections on this string may conceivably be stressed to a point approaching the yield strength in both tension and internal pressure. It is at this time that the operator is most concerned about whether the connections will contain the pressure.

3. Testing and Inspection

The same type of mill defects that occur in tubing are also found in casing. Unfortunately, some defective casing also can and does get by mill inspections. Because of this and the critical service in which casing may be used, some operators inspect and/or test the casing after it leaves the mill. The procedures used for testing and inspecting tubing are also applicable for casing. It should be noted, however, that unlike tubing strings, the entire length of oil strings may be subjected to high internal-pressure differentials. This difference is indicated graphically by Fig. 2 and 3. It is therefore just as important, particularly where conditions similar to those shown in Fig. 5 exist, to inspect the bottom portion of the string as well as the top.

SELECTION FOR CORROSION CONTROL

Inasmuch as the fluid produced from most, if not all, high-pressure reservoirs discovered to date is corrosive, this must be considered in selecting the equipment for completion. Until recently, very little thought was given to the problems of corrosion control until after the well was completed and the two factors, containing pressure and controlling corrosion, were seldom considered together. As a result, corrosion had, in some instances, resulted in severe damage to equipment before any action was taken to control it. Corrosion control covers a broad field and discussion of factors not related to the selection and use of equipment is outside the scope of this paper.

Methods of Controlling Corrosion

There are at least three basic methods which can be and are being used to control corrosion in high-pressure wells.[12] These are by the use of inhibitors, plastic coatings, and corrosion-resistant materials. Two or even all three of these methods may be used at the same time. However, because of economics, only one (or at the most two) of the methods are generally used in a particular well.

1. Inhibitors.

Corrosion control in most high-pressure wells completed to date is being provided by the use of inhibitors. There

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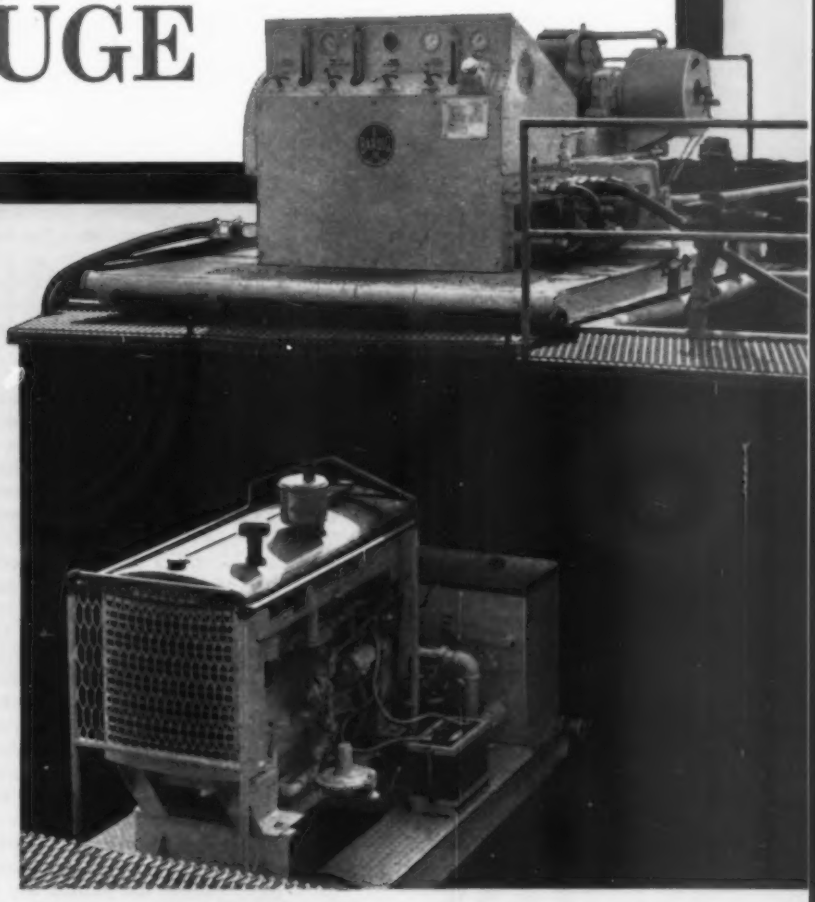

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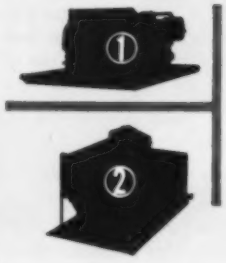

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are several reasons for this. As stated before, some wells have been completed with little consideration given to the problem of corrosion control. Unless coated or corrosion-resistant tubing is run when the well is completed, the only practical solution is to treat. When treating with inhibitors, the operator has some degree of control over the amount of protection he is obtaining. The amount of chemical used and the time between treatments, major factors in the degree of protection obtained, can be varied to meet the variable corrosive conditions that may exist from well to well, or in a particular well over a period of time.

Generally, if corrosion control of a well is to be provided by treatment with inhibitors, there is little or no increase in the initial cost of the completion. In some cases, however, where the tubing string is designed on the basis of ease of treatment with inhibitors, the initial cost of the completion may be increased considerably. These installations will be described later herein. One disadvantage of this method is that when the well is completed with a single string of tubing, it is necessary to shut in the well in order to treat with inhibitors. The changes in temperature and pressure resulting from alternately shutting in and producing the well could conceivably increase the possibilities of tubing failures if the tubing contains defects.

2. Plastic Coatings

Plastic coatings have also been used to control corrosion in high-pressure wells. With this method the surfaces of the equipment exposed to the flowing formation fluids are coated with a corrosion-resistant plastic. A number of such coatings are now available for various well conditions. Although the quality of these coatings has improved considerably during the recent years, there are limitations to this method.

The value of the coating is dependent upon its continuity. Corrosion, possibly accelerated, will occur at any spot where the coating has failed or has been damaged. Considering the approximate 500 lengths of tubing that may make up a string, it is difficult to visualize running string after string of coated tubing without damaging the coating in at least one spot even if the coating was free of defects when applied.

Another factor to consider when using coated tubing is the problem of determining its effectiveness or the condition of the tubing after it is run. The rate of corrosion in tubing is usually determined by measuring the iron content of produced water or by running caliper surveys. If caliper surveys are run, there is a possibility of damaging the coating either with the caliper or with the wire line on which the caliper is run.

Iron counts which indicate loss of metal from corrosion may be misleading. The operator has no way of determining whether the coating has failed and corrosion is general, or whether the coating has been damaged in one or a few spots. A low iron count in the produced fluid could indicate very minor, general corrosion over a large area or very severe corrosion over a small area.

As the result of measurable iron being detected in the produced fluid of wells completed with coated tubing, inhibitors have, in some instances, been used in conjunction with the coatings. The coating insures a minimum area to be protected by inhibitors; therefore, less inhibitor is required than for uncoated strings. The economics of this practice has not been fully developed at this time; however, it may provide the operator with maximum protection at a reasonable cost.

3. Corrosion-resistant Materials

The use of corrosion-resistant materials, particularly as tubing, has been rather limited. One reason for this is the higher initial cost, but the failure of these materials to always perform as anticipated cannot be discounted. In some instances, these materials have not been satisfactory from either a corrosion or a mechanical standpoint and some operators are reluctant to use them. This is perhaps unfortunate, for a truly corrosion-resistant material would greatly simplify the production of corrosive fluids and could possibly result in substantial savings to the oil industry. The failure of the manufacturer to fully understand the conditions under which the tubular goods are expected to perform and the failure of the operator to realize the limitations of these materials are probably contributing factors in the limited use to date. Because of these factors and the variable corrosive conditions that can exist from well to well or in one well over a period of time, extensive use of corrosive-resistant materials, as now available as tubing, will probably remain limited.

Design Types, Relationships

There are also at least three basic tubing-string designs which may be used to complete high-pressure wells. These are the single, concentric, and parallel-string designs (Fig. 6.) The design selected may be dependent upon the method of corrosion control used. The first two designs, single and concentric, are now being used to complete high-pressure wells. The third design, with parallel strings, has not, to the writer's knowledge, been used to date. This design has been considered, however, and may offer some advantages over the other designs.

1. Single-String Design

This is a standard completion where the string is run and set with a packer (Fig. 6-A). Corrosion control can be provided by any of the three methods discussed previously. The advantages of this design are its simplicity and low initial cost. Disadvantages are possible difficulty in killing the well in an emergency and, if inhibitors are used to control corrosion, interruption of flow schedule while treating, as well as the cyclic loading conditions that result from alternately shutting in and producing the well.

2. Concentric-String Design

The concentric-string design (Fig. 6-B) has been used to complete a number of high-pressure wells in recent years. With this design a larger string of tubing is run and set with a packer as in the single-string completion. A smaller string is then run either part or all the way to bottom inside the larger string and suspended without a packer.

Primary advantages of this design are ease of treatment with inhibitors and well control. Inasmuch as this design is based on ease of treatment with inhibitors, the other methods of corrosion control are not usually considered. Possible disadvantages of this design are more equipment in the hole and higher initial cost, restrictions to wireline operations, plugging or bridging of the annular space between the tubing strings, and possible plugging of the smaller-production string which could result in collapse of this string. Collapse of the small-production string should also be considered when killing the well.

In Fig. 7, assume that the surface gas pressure is high, the larger pressure-containing string has failed, and the well is to be killed by pumping down the small-production string. If heavy mud is used, the pressure inside the small string could approach zero when the tubing was filled with mud as shown. At this time, the pressure outside the small-production string would still be high and because the collapse resistance at the top of the small string would be reduced because of tensile loading, collapse may occur. This would indicate that wells equipped in this manner should be killed by first circulating a lighter fluid, such as water, to reduce pressure differentials across the small string of tubing.

3. Parallel-String Design

This design is illustrated in Fig. 6-C. As stated before, it is not believed to have been used to complete high-pressure wells to date. It will be described, however, inasmuch as it may offer some advantage over the other two de-

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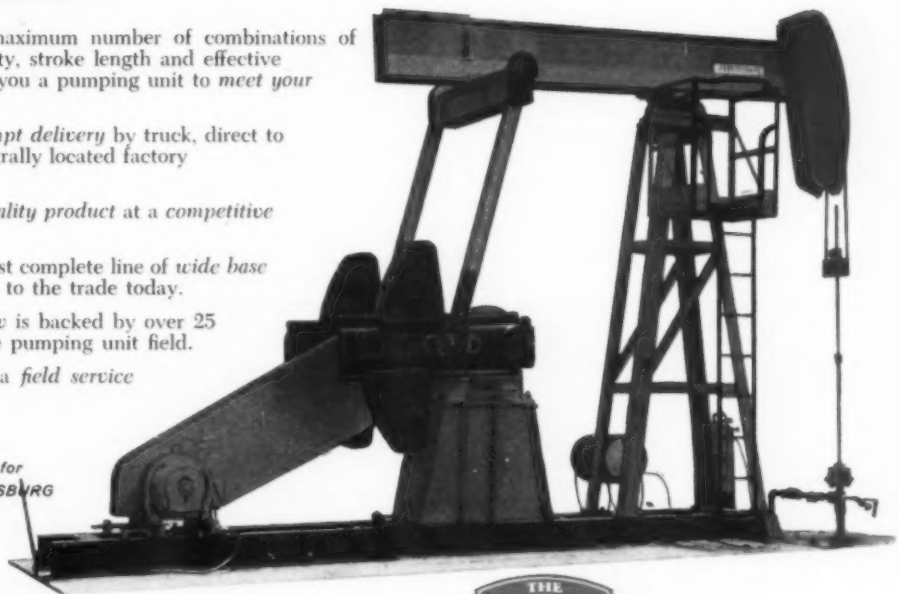

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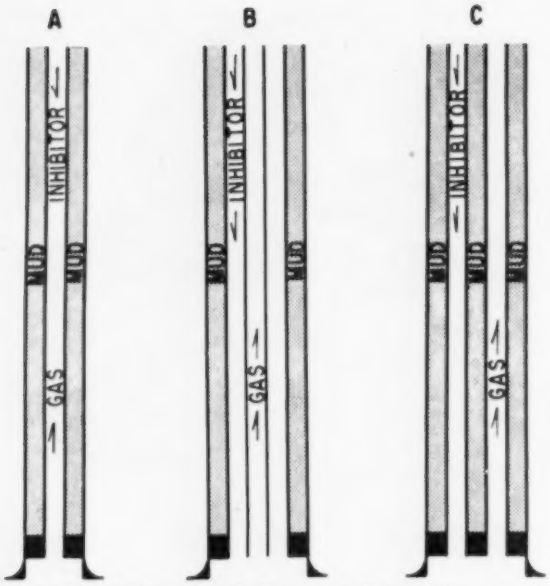

Fig. 6. **Basic tubing string designs** are: (a) Single, (b) concentric, and (c) parallel. First two designs are already being used to complete high-pressure wells; it is not believed that parallel string application has been made, although its use in the future may offer some advantages.

Fig. 7

Fig. 8

Fig. 7. **Filling the tubing** with heavy mud to kill this well could force pressure inside the small string to approach zero, should surface gas pressure be high, and the larger pressure-containing string fail. Killing the well with water would reduce pressure differentials across the small string. Fig. 8. **A check valve** in the treating string would make it possible to reduce pressures required to inject inhibitors at the surface. Such an arrangement might justify lower strength tubing.

signs. The primary advantages would be, as in the concentric-string design, ease of treatment and well control. Because this design is also based on treatment with inhibitors, the other methods of corrosion control would not generally be applicable. With this design, there would be no restriction as to wire-line operations and pressure bombs, storm chokes or other equipment could be run as in a well completed with a single string of tubing. High external-pressure differentials would not occur during killing operations or in the event the production string was plugged.

By using a check valve in the treating string, it would be possible to reduce the pressures required to inject inhibitors at the surface. This reduction would be equivalent to the hydrostatic head provided by the fluid used as a carrier for the inhibitor. This is illustrated in Fig. 8. Under these conditions, lower-strength tubing with standard connections may be justified for this string.

Disadvantages of this design are more equipment in the hole and greater initial cost, as is true for the concentric-string design. In addition, there is also the possibility of trouble when running one string of tubing parallel to another. A few years ago, this method of completing high-pressure wells would have been out of the question. However, with recent improvements in the development of equipment and practices for dually completing wells with parallel strings of tubing, this type of completion may now be practical.

Conclusion

No attempt has been made to recommend minimum design standards. This is up to the individual operator and may be dependent upon many other factors. Safe completions can be made with any design as long as this design is based on maximum operating conditions and the quality of the equipment being used.

Considerable progress has been made in the manufacture and in the use of tubular goods in recent years. There is, however, much room for improvement. Failures still occur. Some can be traced to manufacturing errors and others to misapplication or abuse by the user. Additional failures will probably occur in the future, but these can be reduced to a minimum by the manufacturer improving the quality of his product and by the user putting more emphasis on proper design and use in the field.

Acknowledgment

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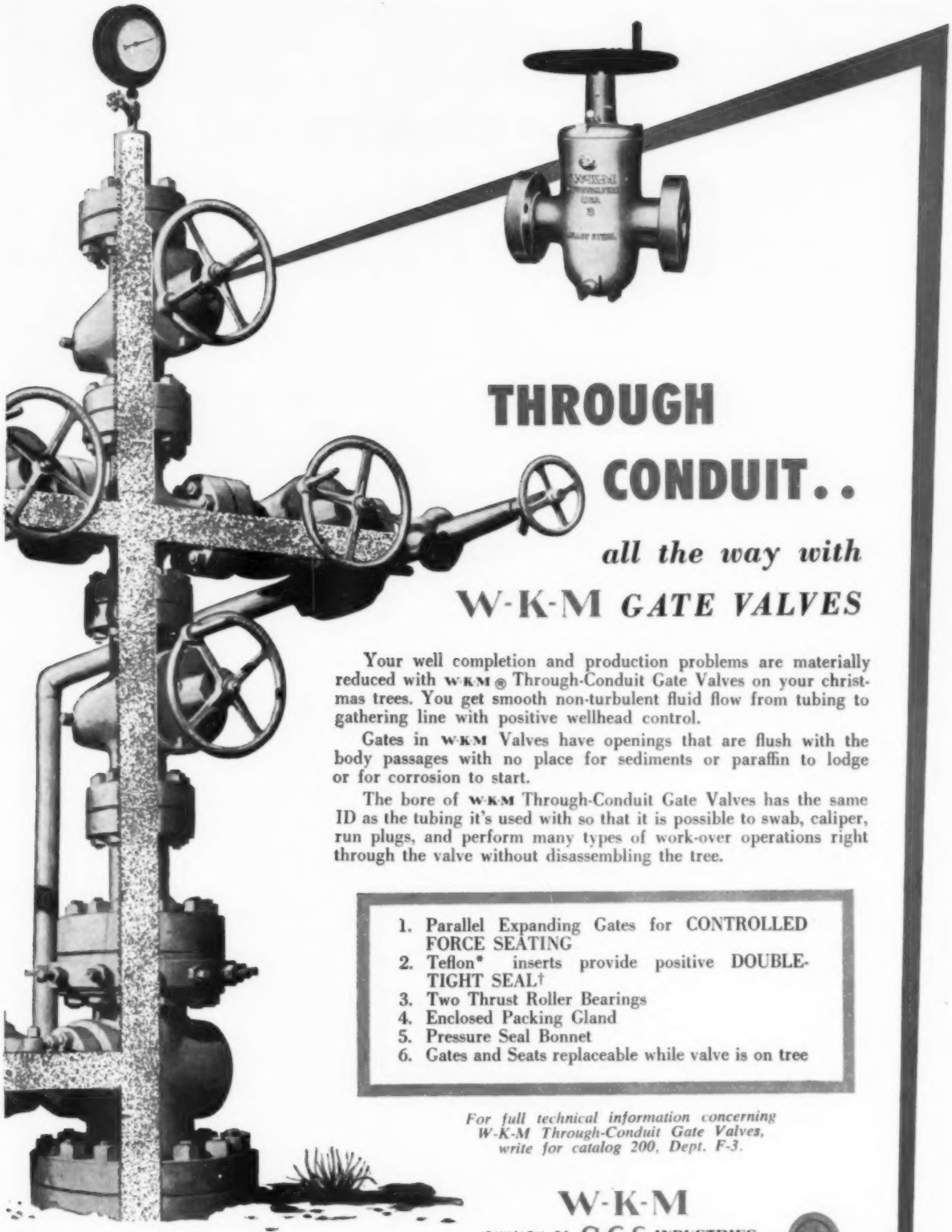

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Laboratory Flow Measurements Used To . . .

EVALUATE PERFORATING EFFECTIVENESS

Permeability of core targets before and after perforating used to study perforating techniques and completion fluids

TREMENDOUS STRIDES made in gun perforating of wells has brought about the need for a "yardstick" by which to evaluate well perforating techniques. Although exact down-hole conditions cannot be duplicated in the laboratory in every case, an approach has been made to check the performance of perforating under semi-simulated conditions, where temperatures to 190 F and pressures of 1500 psi can be obtained. Not only have these "flow laboratories" brought about big improvements in perforating . . . both the bullet and shaped charge . . . but, these flow tests have proved the validity of using a completion fluid in the hole while perforating.

In Los Angeles, California, Lane-Wells Company operates, as part of its research and development program, a modern, well-equipped flow laboratory to test perforating techniques under semi-simulated down-hole conditions.

Well Flow Index

A term called "well flow index" is used for comparative results of perforating tests made on core targets. It is briefly defined as the ratio of the flow capacity of a standard core target before perforation to the flow capacity after perforation under semi-simulated well conditions. If the flow index of one perforating method is slightly more than, say, 0.5, and the flow index of a second perforating technique is near or slightly greater than 1.0, it can be concluded that the latter perforating method will provide better flow characteristics of a reservoir under similar conditions.

Flow lab tests. Berea sandstone, cut parallel to the bedding plane, is used in the laboratory flow tests. Samples measuring 3 9/16-in. in diameter and 12-in. long are standard test targets. For comparative purposes in one set of tests, these core targets are cut from the same large block of Berea sandstone.

Core targets are cleaned, marked for identification and dried in an oven for at least 16 hours at 275 F. After cooling, they are measured and placed in an evacuation cell where a 30-in. (Hg) vacuum is maintained for 16 hours. It is then saturated with 30,000 ppm salt water for 2 hours and then flooded with kerosine in a Hassler unit until minimum water saturation is reached.

Permeability to kerosine is carefully determined until a constant permeability is obtained. The core is then weighed and cemented into a target case with hydromite, a resin gypsum plastic.

Continued on page B-77.

Laboratory flow tests on perforated core targets are controlled from this panel by the test engineer. On the concrete wall separating the operator from the firing or test chamber in a separate room are mounted measuring devices and pressure control equipment.

G. ALLAN MacNAMARA

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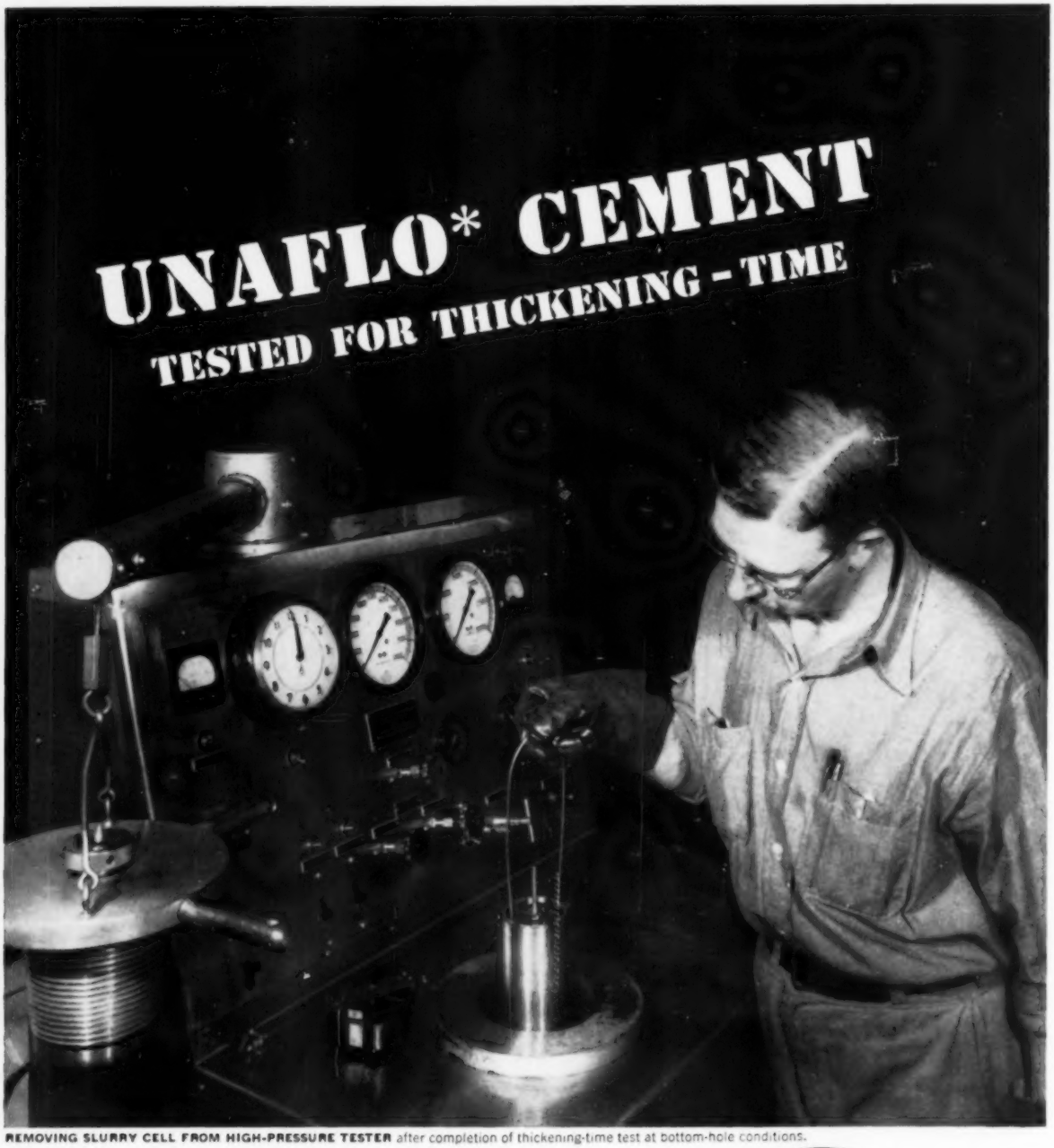

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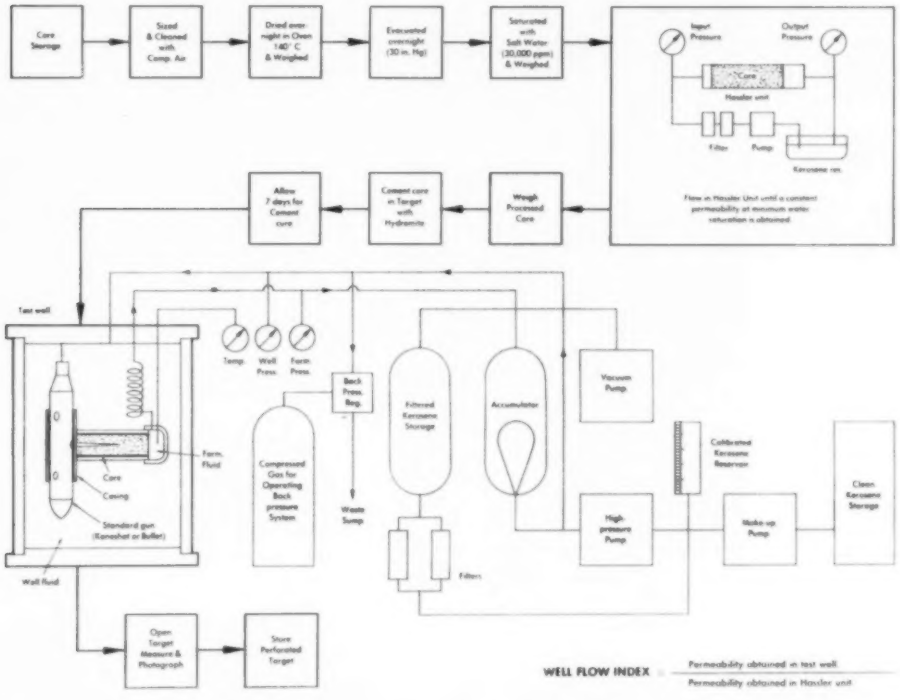
1. Preparing core target involves drying and saturating Berea sandstone with salt water and kerosine prior to permeability determinations. In foreground are prepared targets.

2. Permeability determination prior to perforating the Berea sandstone core is performed on this Hassler unit. Permeability to kerosine is determined.

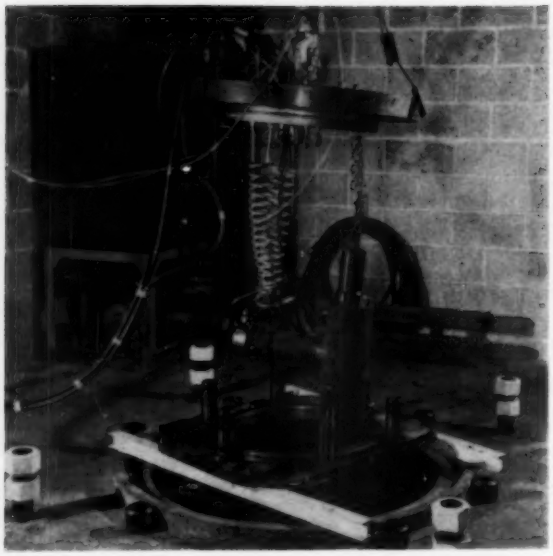
The target case, a tee-shaped assembly of 4½-in. drill pipe welded to 5½-in. N-80 casing, as shown in Fig. 1, is then loaded with a short section of a standard gun used in the field. It contains only one shot directed through the casing section of the target case and into the core sample.

The completed assembly, shown in Fig. 3, contains control leads for: (1) Shooting, (2) reservoir fluid input; (3) reservoir pressure; (4) well fluid pressure, and (5) temperature. This completed assembly is then lowered into a 2-in. steel wall cylinder and the control head bolted in place. A safety steel plate covers the test assembly in the sump.

The chamber is pressurized and heated for at least two hours until temperature stabilizes at 190 F. Pressure is applied inside the simulated well bore and behind the core sample. The amount of pressure applied in each



Schematic diagram of Lane-Wells flow laboratory indicating steps in preparing target for perforating, the test chamber, methods of controlling temperature and pressure as well as recording data, and disposition of target.



3. Test chamber assembly with one-shot gun in place in the prepared perforating target. Pressure chamber has 2-in. thick steel wall. Head has O-ring seal and is bolted in place.

4. Pressure tight chamber with control leads for controlling pressure, temperature and flow is lowered into sump which is later covered with a safety plate bolted in place.

case depends upon the type of perforating gun being tested. If the solid or retrievable type perforators (for both bullet or shaped charges) are used, a differential pressure into the core is established. This is accomplished by pressuring up the casing to about 1200 psi, and behind the core to about 1000 psi, giving a 200 psi differential into the core.

Expendable or through-tubing shaped charges are usually tested with a 200 psi differential into the well bore. Pressure in the core is built up to about 1200 psi, with casing pressure at 1000 psi.

When the desired pressure differential and temperature have been established, the gun is fired from the control panel shown in the first photo, mounted on a concrete wall separating the control room from the test chamber.

If the retrievable carrier type gun is used, the kerosine flow rate is stabilized through the perforated core from the casing side due to the 200 psi differential into the core, the casing pressure being greater than the pressure in the core. The pressure is then equalized, and the kerosine is flowed through the core and into the well bore. This flow is accomplished by reversing the original pressure conditions. Pressure behind the core is increased gradually to about 1200 psi, with 1000 psi in the well bore.

Approximately 7000 cc of kerosine are flowed through the core (or until flow rate is equalized) into the well bore . . . or until a constant permeability is indicated. Pressure in the test chamber is reduced and the gun and target are removed.

After checking for leaks and inspecting the target, it is cut open for further study. Fig. 5 shows a target that has been sawed in half for visual examination and measurement.

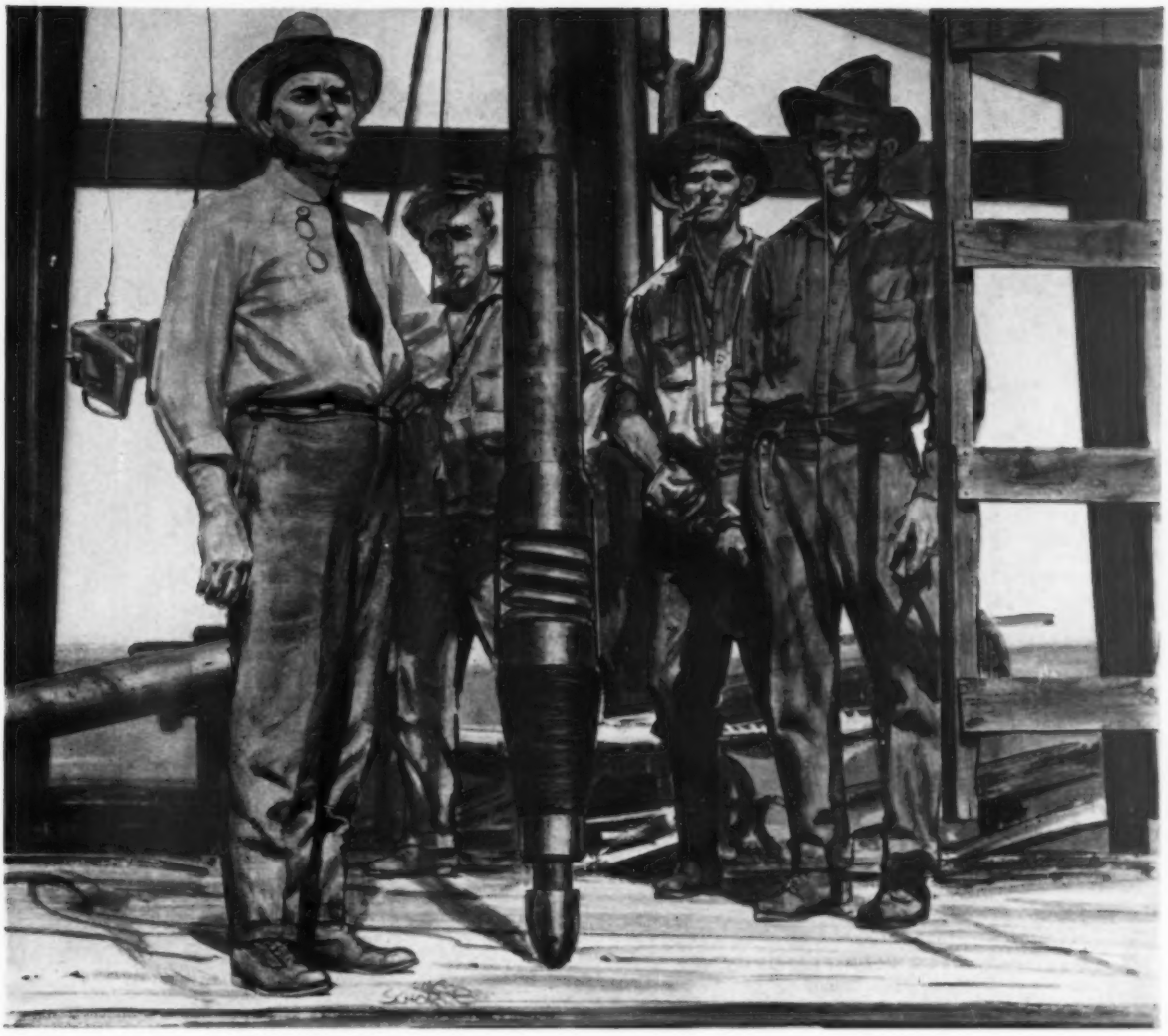
5. Target sawed in half after the flow test for visual inspection shows hydromite cement sheath and perforated hole. Ruler measures size of perforation.

Comparative results. The permeability of the core target before perforating is carefully calculated from data taken in the Hassler unit. This is referred to as K_1. Permeability of the core target after perforating under simulated conditions of well flow in the test chamber are calculated from data taken during the flow test. This is K_2. The ratio K_1/K_2 is the well flow index as determined for that particular perforating gun and charge.

Benefits from tests. As a result of the increased accuracy in evaluating gun perforating, a number of benefits to industry have been derived. Many improvements have been made in gun perforating, not only in the gun carriages themselves, but in the explosives used in bullets and shaped charges. Perhaps of equal value has been the study of completion fluids used in perforating. Well flow indexes for the same type of perforating are definitely lower when the differential is into the formation. And, it has been proved that colloidal mud particles have a tendency under a differential into the formation to plug flow.

Further studies definitely indicated that a pressure differential into the well bore results in a higher well flow index. These investigations have indicated the benefits from using salt water, fresh water, oil, or special well completion fluids in the well during completion.

The flow laboratory will continue its usefulness in further studies on perforating and well completion fluids to evaluate a number of factors which influence the productive capacity of a well. ★ ★ ★



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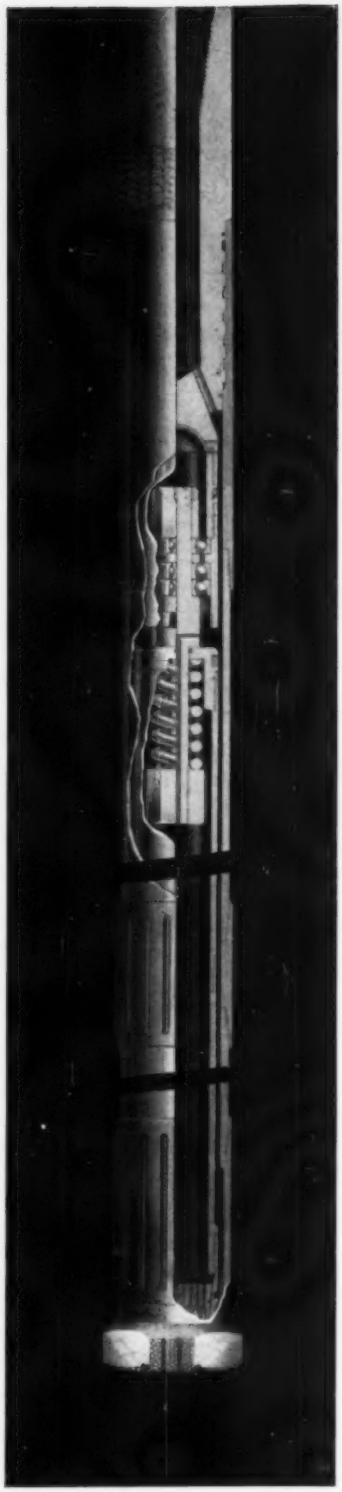

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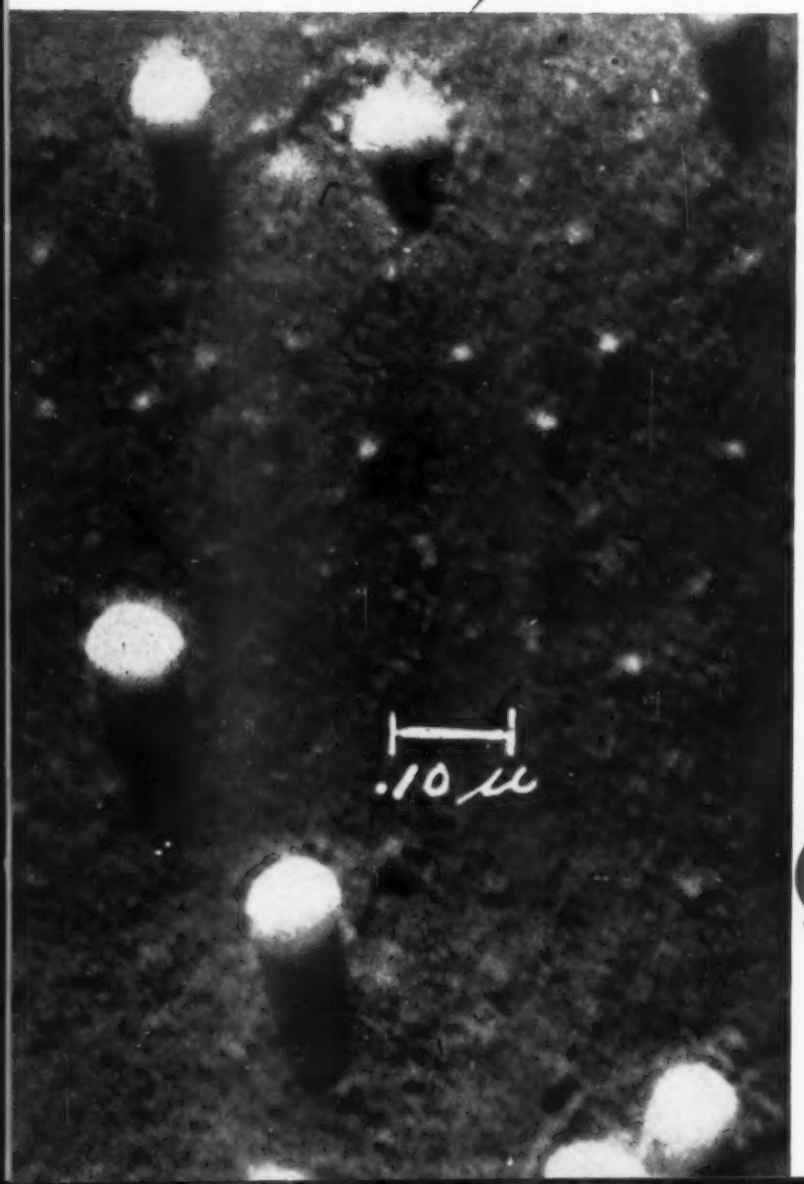

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Development of...

A High-Speed Low-Torque Drilling Device

Turbine-driven tool offers solution to drilling hard formations at reduced bit weight in crooked hole country

George E. Cannon
Humble Oil and Refining Company, Houston, Texas

IN 1949 a research organization located in Texas undertook an investigation sponsored by an organization formed to investigate new methods of drilling to determine the applicability of high-speed low-torque cutting elements to the drilling of wells. This work encompassed a survey of the literature and patent art and a rudimentary laboratory investigation of the ability of a wheel set with tungsten carbide cutters about its periphery to drill rock when rotated about its axis with a flexible shaft drive and with the entire unit rotated about an axis 90 deg to the wheel axis. Drilling rates up to about 20 ft per hr were obtained in lime while drilling a 4¼ in. hole with the experimental device.

This work was dropped by the sponsoring organization since it was felt to be too closely related to conventional rotary drilling practice and, therefore, outside the scope of the organization's purpose. Since Humble Oil and Refining Company had patent rights on a turbine-driven drilling tool of the type making use of such a cutting technique, Humble assumed the sponsorship of the development program. Under this development agreement and extensions thereof, laboratory and field development work was continued through the fall of 1955. In the summer of 1956 a bit manufacturing company undertook further development of this tool.

Based on paper by same title presented by author at the 32nd Annual Fall Meeting of the Society of Petroleum Engineers of AIME in Dallas, Texas, October 6-9, 1957, and published here by special permission.

Development of Drill

The original work conducted served merely as background since the work to be done for Humble was the development of a tool for field use. This required the design and building of a suitable surface test rig, determination of the most suitable materials for erosion resistance and cutting ability, and the development of operational techniques for use in the field. The tool was originally designed to drill 6¾ in. hole. The cutting elements were shaped tungsten carbide teeth set in the rim of an impulse turbine wheel mounted on an inclined yoke inside a drill body in such a manner that an oversized hole with respect to the wheel diameter was drilled to compensate for cutter wear. The wheel was hydraulically loaded through a piston and linkage arrangement and was spring loaded in a retracted position. A schematic drawing of the tool is shown in Fig. 1, and a photograph is shown in Fig. 2. The original 6¾ in. tool was used only in the laboratory tests since by the time they had been completed enough design deficiencies had become apparent to make the building of a new tool desirable. This new tool was built to drill 8⅝ in. hole.

Original emphasis was on the development of a tool for drilling hard formations; however, tungsten carbide cutters proved unsuitable for this type of service and a limited series of tests using diamonds also proved unsatisfactory. Since the bulk of the hard formation drilling is accomplished with water as the drilling fluid, erosion problems tend to be minimized and for that reason the turbine wheel and nozzles

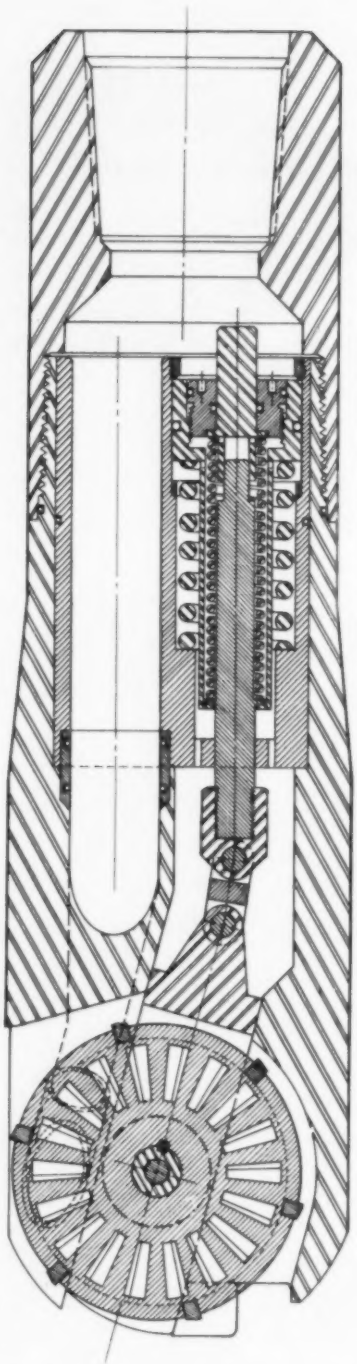
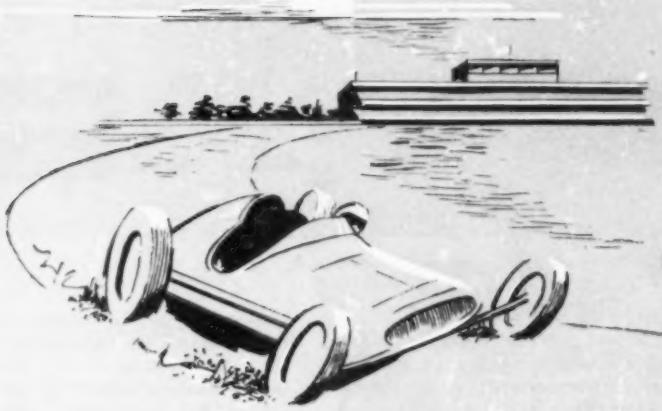


FIG. 1. Cross section of the turbine drill shows hydraulic-loading piston, spring-loaded retractor assembly, mud races, and mud-driven offset cutting wheel with cutters set around the periphery. In drilling, the cutting wheel spins about its axis while the entire tool is rotated about the axis of the drill pipe.



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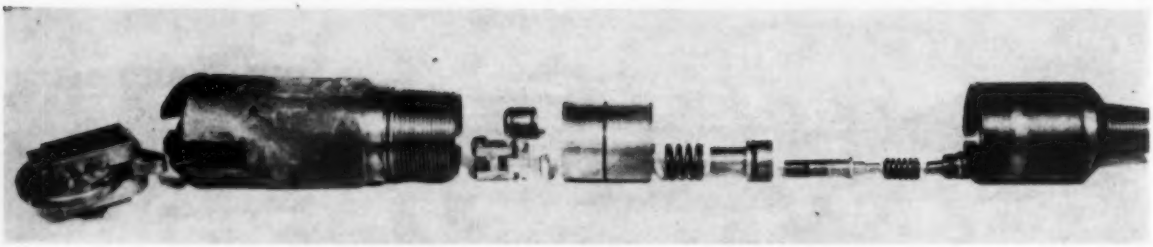

FIG. 2. Exploded view of the experimental turbine drill.

had been made of heat-treated steel. Due to the limited cutter life the objective was changed and work was directed toward the development of a device for drilling the softer coastal formations.

Field Testing

The first field test was conducted in the Southwest Texas area April 22, 1953, using the new tool. Two wheels had been built, one equipped with ball bearings for laboratory testing and one equipped with rubber journal bearings for field testing. However, the rubber bearing turbine rim slipped sideways when repeated heating and cooling in connection with the installation of the cutting elements had destroyed the shrink set between the rim and the turbine wheel. For this reason, it was necessary to use only the ball bearing equipped wheel on the test.

Initial penetration rate obtained was 100 ft per hr but decreased rapidly so that only 13 ft were drilled in 10 minutes and the succeeding 3 ft required 15 minutes. The tool was pulled and it was found that the ball bearings had failed permitting sufficient deflection of the turbine to cause a stoppage. In this brief period, considerable erosion had also been experienced. The turbine buckets as well as the turbine rim were very badly damaged as well as the heat-treated tool steel nozzle. One of the cutting elements was broken, and the others were rounded on the cutting edges by the high wheel speed.

The tool was rebuilt and again field tested the next month in the same area. The test was conducted following a routine round trip to change bits and the formation proved to be an extremely hard sand streak. While drilling some 6 in. of this streak, the cutter teeth were worn flush with the rim of the turbine and the head of the tool was severly abraded. From the results of this test it was evident that the decision to try to develop a soft formation rather than a hard formation drill had been a proper one and that redesigning of the tool to provide increased erosion resistance was required.

Laboratory Modifications

Following an extensive materials testing program, a laboratory testing procedure to determine the best cutter design and material, and a study of the cutting mechanism of a drill of this type, the third tool was built to drill 8⅝ in. hole, and laboratory testing of this tool was completed by the fall of 1954. This first field test of the new tool was conducted in September of that year. This test was conducted in the North Katy field of Harris County, Texas.

A modified bumper sub was utilized to provide a by-pass for circulating around the tool should this be necessary prior to a round trip or due to some other operational consideration. However, the loading imposed by the bumper sub proved excessive in that it tended to stall the turbine. On this particular test a total of only 29 ft were drilled in three hours. On the second test in this same field, without the bumper sub, the tool drilled 87 ft at an average rate of 13 ft per hr. This second test was terminated when a pump valve failed and a part of the valve was pumpd down the drill pipe through a washed out strainer. Results of this test were somewhat encouraging since the bit used ahead of the turbine had averaged only 10 ft per hr.

Following the test the tool was modified to provide an additional watercourse to operate in parallel with the turbine for cutting removal. This work and further laboratory testing was completed early in 1955, and two additional field tests both in the Galveston Bay area were conducted. On the first of these tests 127 ft were drilled at an average rate of 42½ ft per hr with a maximum rate of 100 ft per hr. This test was terminated when the turbine failed to retract when making the fourth connection after the test was started. Spinning of the drill pipe with the turbine in a extended position destroyed the wheel and only the hub was recovered when the tool was pulled.

The examination of the tool after the test indicated that sand had wedged between the piston, the tool body, and the O-ring seal indicating that a wiping-type seal should be used on the loading piston. This modification was made and the last test of this tool was conducted July 1955. On this test approximately two feet of hole was made when the drill stopped and when pulled it was found that all of the cutting teeth were worn or broken off approximately flush with the rim of the turbine.

To summarize this phase of development, it appeared that a tool of this general design could be made to drill at low applied loads if a suitable cutter material could be found. The use of rubber bearings and tungsten carbide alloys apparently minimized the effects of fluid erosion and the basic principle of the drill had been demonstrated.

Diamond Cutting Element

Since cutting element failure appeared to be the principal weakness of

The Author

George E. Cannon *attended the University of Illinois and Austin College, where in 1929 he received his bachelor and master degrees in chemistry. Upon graduation, he joined Humble Oil & Refining Company and was assigned to the production research division in Houston. In 1938 he was made assistant head of the production research division. Later in the year he was transferred to the petroleum engineering division and placed in charge of the drilling practices section.*

He is a member of the Texas Society of Professional Engineers, the Society of Petroleum Engineers of AIME, the American Chemical Society, and American Petroleum Institute.

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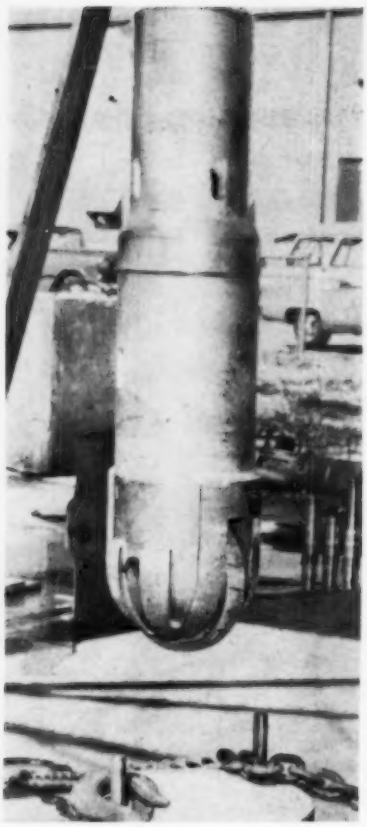


FIG. 3. Assembled turbine drill with diamond-set cutter wheel and reamer body.

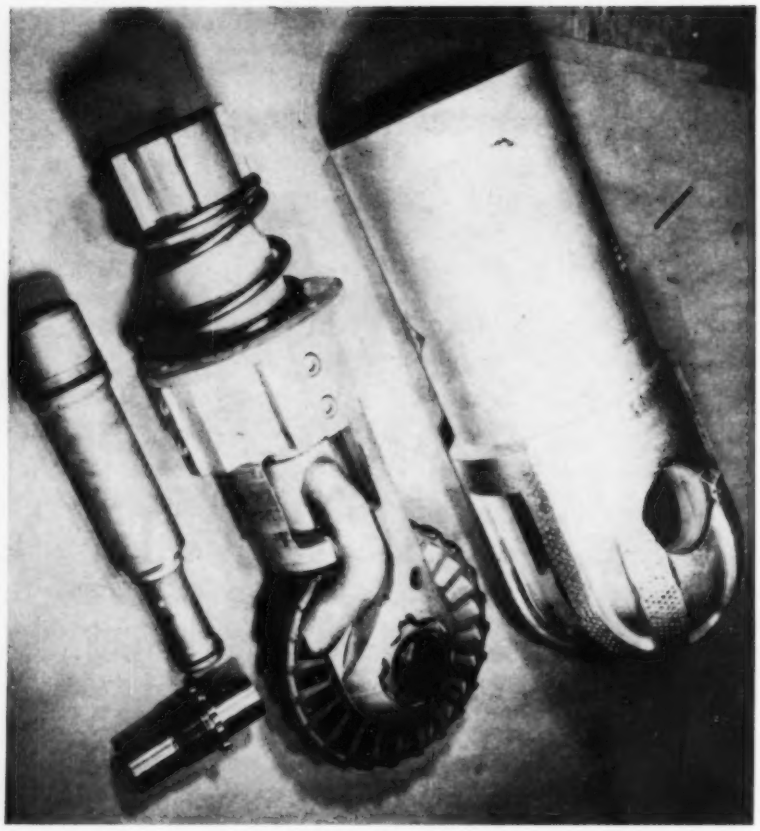


FIG. 4. Main components of experimental turbine drill include hydraulic-loading piston, centered mud-driven cutting wheel, and diamond reamer body.

the drill, consideration was again given to the use of diamonds. As a result of the discussion of the problem with a manufacturer of diamond bits, they became interested in the further development of the drill and commenced development work in 1956.

An 8⅞ in. turbine drill, shown in Fig. 3 and 4, was designed and built for field test. This tool differed from that built for Humble originally in that the wheel was centered and the gage section was maintained by a diamond set reaming shell. Down thrust on the wheel was provided through wireline retrievable mandrels. The original turbine was retracted by a spring and loaded hydraulically; this retraction was not considered necessary for the new design since the wheel is under hole diameter.

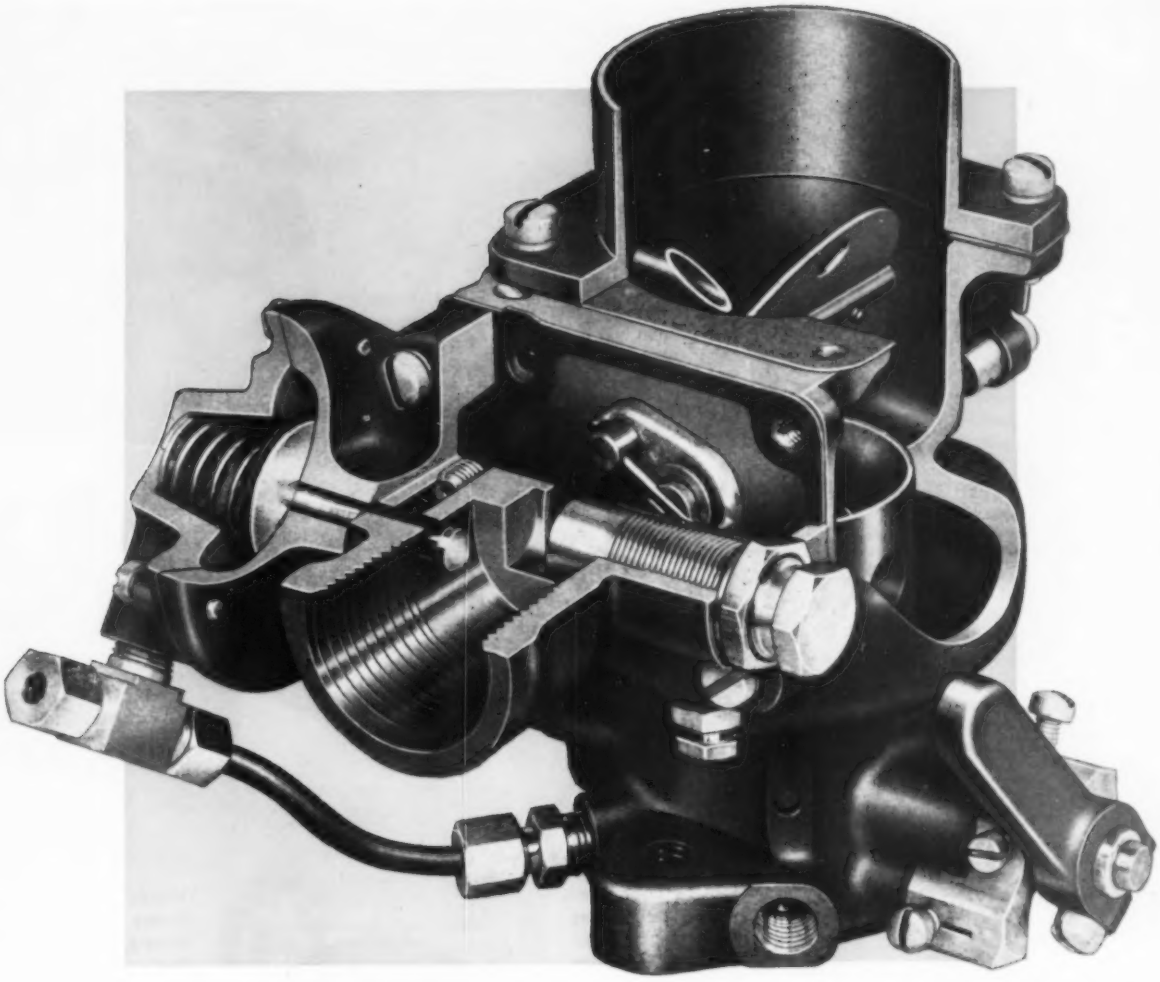
The original tool was field tested on three occasions; the first was in the Pandale area wildcat, Southwest Texas area, at a depth of 3500 ft.

On this test a 8⅞ in. diamond core bit was run ahead of the turbine and cored four feet at a rate of 14 min per ft. The turbine drilled six feet below the coring point at a rate of 12 min per ft approximately 15 percent faster than the coring rate. The principal wear observed at the test site was to the nozzle side thrust bearing and to the axle which supports the cutting wheel. Erosion was not evident and diamond loss to both the reaming shell and the turbine wheel appeared to be negligible. The equipment was returned to the manufacturer for examination and necessary modification for further testing.

This further examination indicated that the thrust bearing wear was due to the rubber molding procedure which had been utilized and that failure was due to peeling of the thrust pads rather than abrasion. Wear on the journal bearings indicated that a high rate of turbine rotation had been obtained and that a more wear resistant material would be required for the wheel journals or axles. Drilling performance was disappointing and believed due to the cutter design on the wheel utilized. These noted deficiencies were corrected and the turbine was field tested for the second time in the Hutex field in West Texas.

On the first run of this test the tool drilled from 4389 ft to 4400 ft in 2½ hours. A total of three hours running time was accumulated on the tool with the maximum drilling rate obtainable being 8 min per ft. Examination of the tool after this run indicated that while the wheel had been turning it had not been loaded since the wear marks were at the crown rather than at the edges where drilling action would occur. In an effort to increase the down thrust on the wheel a larger mandrel was utilized in the second run. After one hour of testing at a wide range of weights and rotary speeds during which an insignificant amount of hole was made, the tool was pulled. Examination of the tool indicated that in some manner the axles had been broken loose from the wheel and lost in the hole. The hub of the wheel and the turbine had become separated but were recovered with the tool. At sometime during the operation after the axles were lost, the turbine, running free in the hole, had cut a groove approximately ¼ in. deep in the yoke. Both the thrust and journal bearings were in good shape indicating that at least in this direction considerable improvement had been made over the first test.

Principal result of this second test was the conclusion that regardless of the cutting structure on the wheel the lack of drilling performance had been due to the inability to load the wheel. Consideration of this problem together



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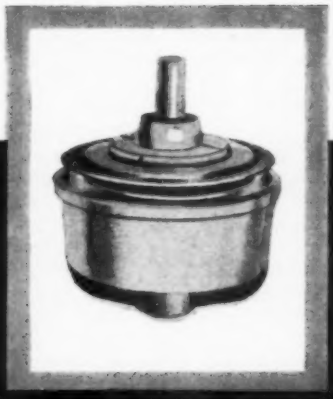

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with the observed pressure drop across the reaming shell led to the conclusion that this pressure acting upon the enlarged cross section of the yoke, which may be seen in Fig. 4, was forcing the wheel to its upper or retracted position. This assumes that a reasonable seal existed around this enlarged section and the keys which are located at 90 deg around it.

Structural Modifications

Pressure across the reaming shell from 50 to 75 psi under the conditions of operation of this test was applied to the bottom of this enlarged section and the reduced pressure was applied to the top of the section through circulating ports which can be seen in Fig. 3. The fact that the wheel, running without bearings and at a poor nozzle angle, had been able to groove the yoke was believed to indicate a reasonable potential drilling ability.

Following this test the tool was modified to close the circulating ports, flats were cut on the enlarged section of the yoke to prevent a dash pot effect, and new axles of carbon steel with chrome-plated wear surfaces were made since this axle gave better wear performance and since cracking of the tool steel axles was believed to be the cause of the axle failure. A new wheel was also made using a different technique calculated to give a better bond at the steel hub-carbide section interface. The third test was then conducted in the Means field of West Texas.

On the first run at a depth of 3944 ft no significant drilling performance could be obtained with either a large or small mandrel. Hole conditions were such that the pipe had to be spudded to reach bottom and a trip out of the hole required as much as four to five hours due to tight hole through the red bed sections. For this reason, it was believed that the tool had probably been fouled while going in the hole and the wheel had never been able to reach drilling position. No wear marks could be observed on the wheel.

In an attempt to remedy this situation a steel spacer was obtained and used on the second run at a depth of 4410 ft to maintain the wheel in a semi-extended position. On this run the 40 ft of fill-up on bottom was washed down in approximately 30 minutes and an attempt was made to find operating conditions under which the tool would drill. It was found that under a wide range of weights and rotary speeds, the tool would still not drill satisfactorily. The tool was then pulled, and it was found that the turbine wheel and one axle had been lost in the hole. Cause of this failure is not known.

Based on results of these three tests, the tool was rebuilt in the fall of 1956 to drill 7⅞ in. hole. The 7⅞ in. tool has now been field tested on four occasions in the West Texas area.

The original mechanical difficulties now appear to have been overcome, and on these last four tests a total of 280 ft has been drilled at a rate from one-third to two-thirds the rate obtained with rock bits in comparable sections, and with even better results when reduced weight was required with the rotary as is shown in Table 1.

The principal anticipated application of this tool is in hard formations which would normally have to be drilled with reduced bit weight due to hole deviation characteristics. Since the drill operates without the application of bit weight, this feature should provide a means for obtaining a straight hole through a normal crooked hole zone with increased bit life and drilling rate. Application of this tool or modification thereof to other drilling conditions is to be investigated.

Table 1. Comparable Turbine and Rotary Performance in West Texas.

Test	Operation	Ft*	Hr	Ft per hr
1	Turbine	109	7.3	15.1
	Rotary	219	10.9	20.0
Remarks: Weight on rotary slightly reduced account of deviation.				
2	Turbine	51	12.1	4.2
	Rotary	60	6.1	9.8
Remarks: Normal weight on rotary.				
3	Turbine	70	9.9	7.2
	Rotary	220	10.7	20.5
Remarks: Normal weight on rotary.				
4	Turbine	50	10.9	4.6
	Rotary	30	7.9	3.8
Remarks: Weight on rotary approximately one-half normal account of deviation.				
Total/Average first three tests.				
	Turbine	230	29.3	7.9
	Rotary	499	27.7	18.1
Total/Average all tests				
	Turbine	284	40.2	7.0
	Rotary	529	35.6	14.7

*Rotary performance from Driller's Tourly Reports and does not necessarily reflect total bit footage. Turbine footage is total.

Future of the Device

Principal effort, however, on these tests had been directed toward determining the operating techniques necessary for use of the drill and to determine its operating characteristics rather than to obtain maximum footage. Tests are now being planned to determine the economic applicability of the drill.

Acknowledgment

The author wishes to thank the management of Humble Oil and Refining Company for permission to publish this paper and to acknowledge the assistance of his associates in the engineering and operating divisions who assisted in this development. ★ ★ ★

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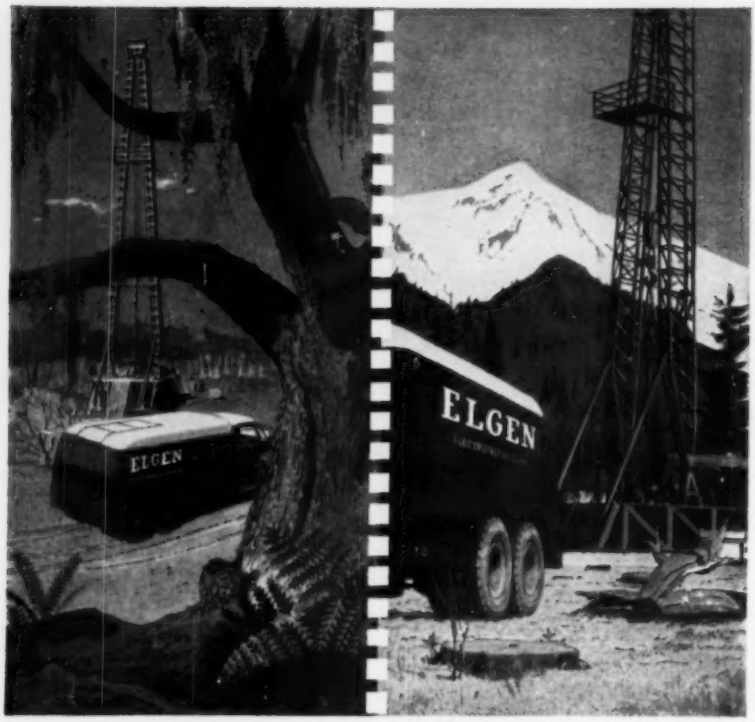

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Canadian Petroleum Association Chooses New Director

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At the meeting 13 directors were chosen by the voting members to serve on the 25-man board.

Elected for a two-year term were: A. G. Bailey, Bailey-Selburn Oil & Gas Ltd.; A. F. Beck, Canadian Export Gas Ltd.; R. C. Brown, Hudson's Bay Oil & Gas Company Ltd.; A. C. Detmer, Mobil Oil of Canada, Ltd.; G. E. Dunlap, Sun Oil Company; Bart W. Gillespie, Home Oil Company, Ltd.; Paul L. Kartzke, Shell Oil Company; G. L. Knox, The California Standard Company; C. O. Nickle, Conick Petroleums; V. Taylor, Imperial Oil Ltd.; T. W. G. Thomson, Texaco Exploration Company; O. I. Torkelsen, The British American Oil Company, Ltd.; D. K. Yorath, Canadian Western Natural Gas Company, Ltd.

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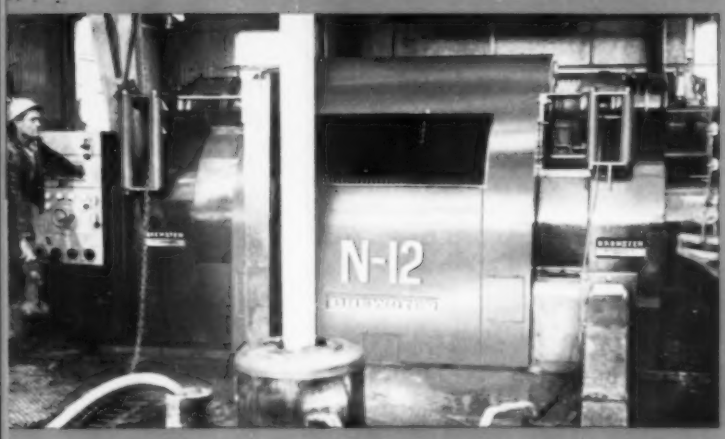

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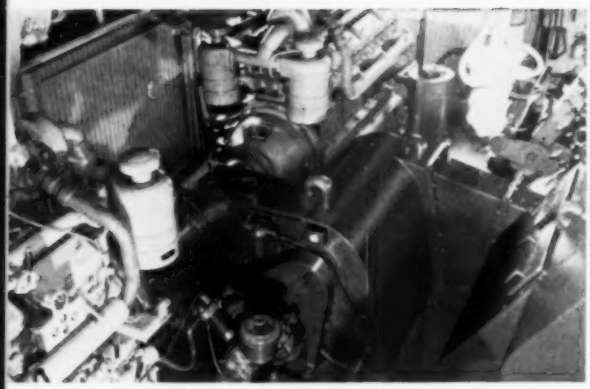

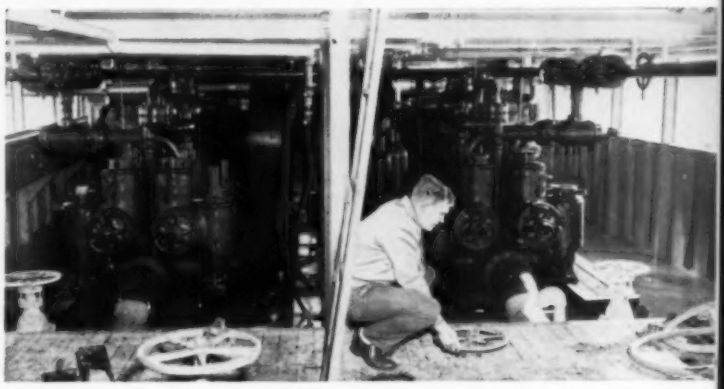

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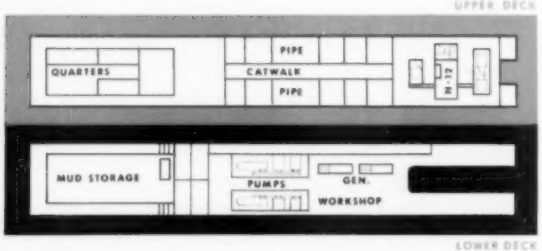

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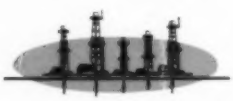

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Houston, Texas

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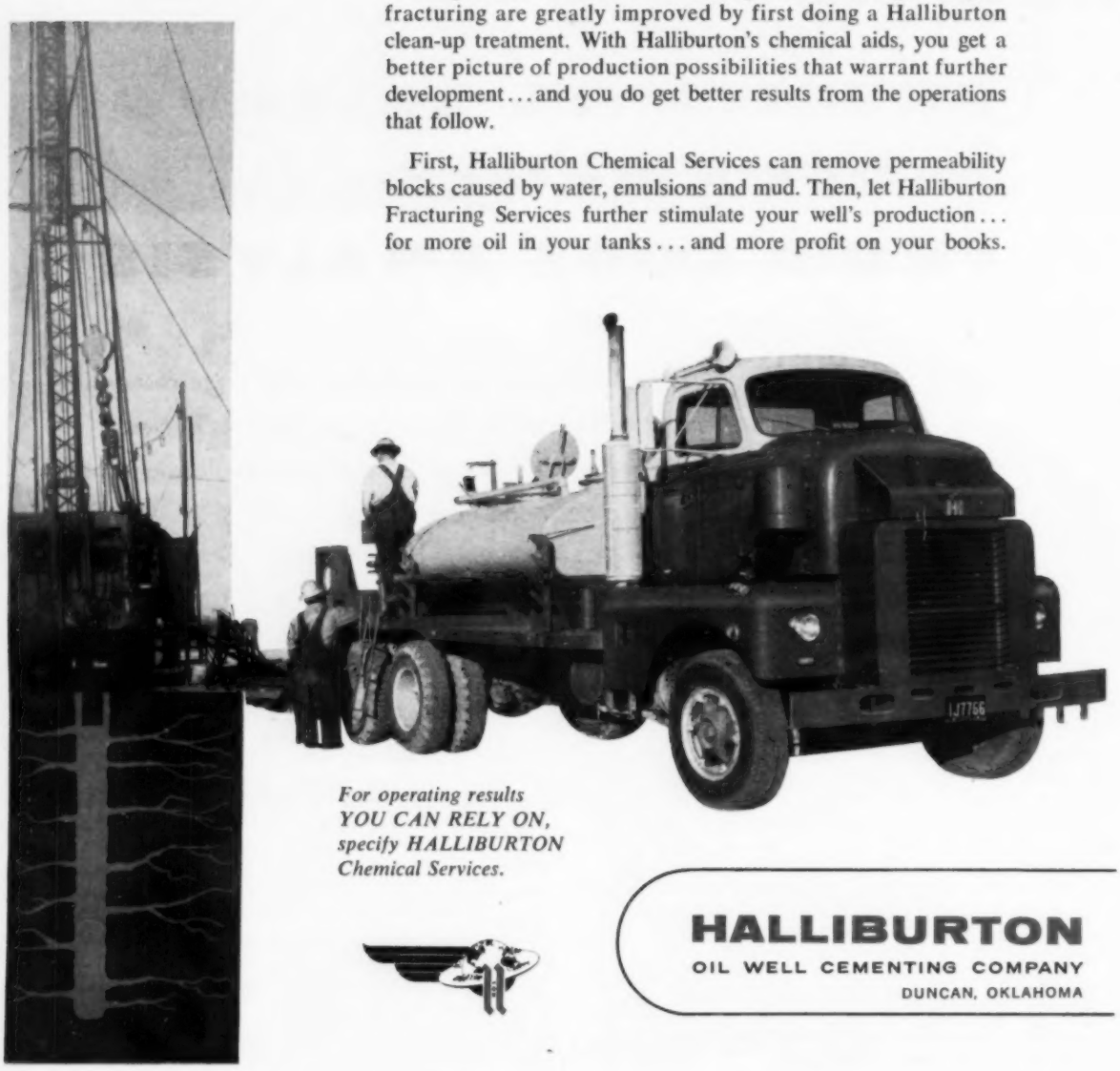

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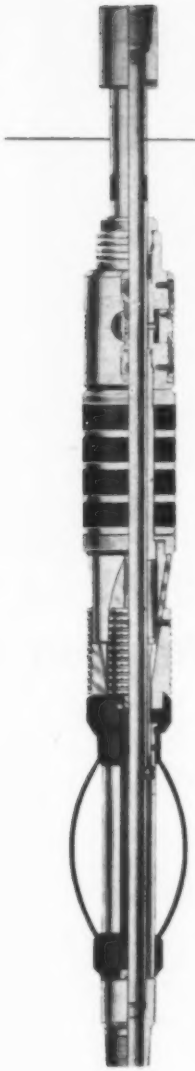

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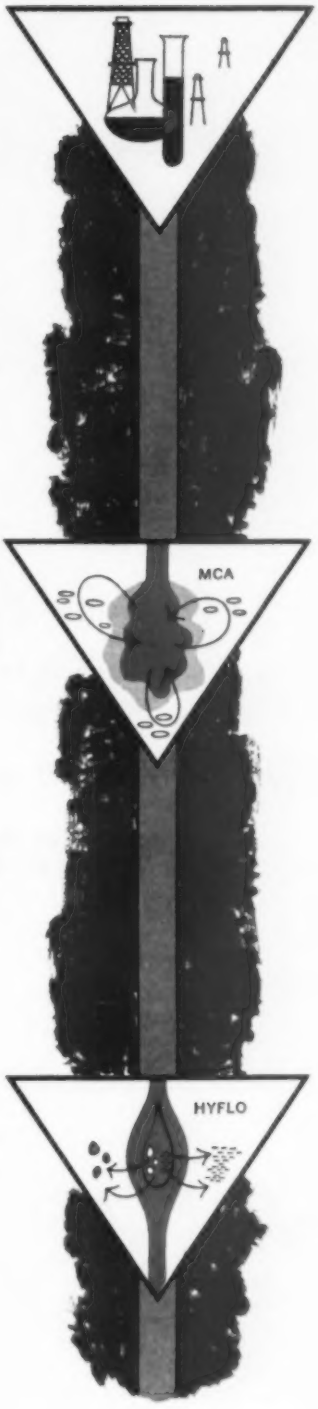

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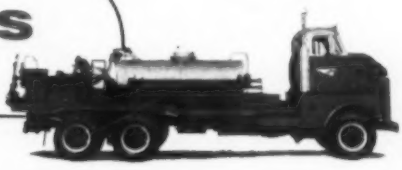

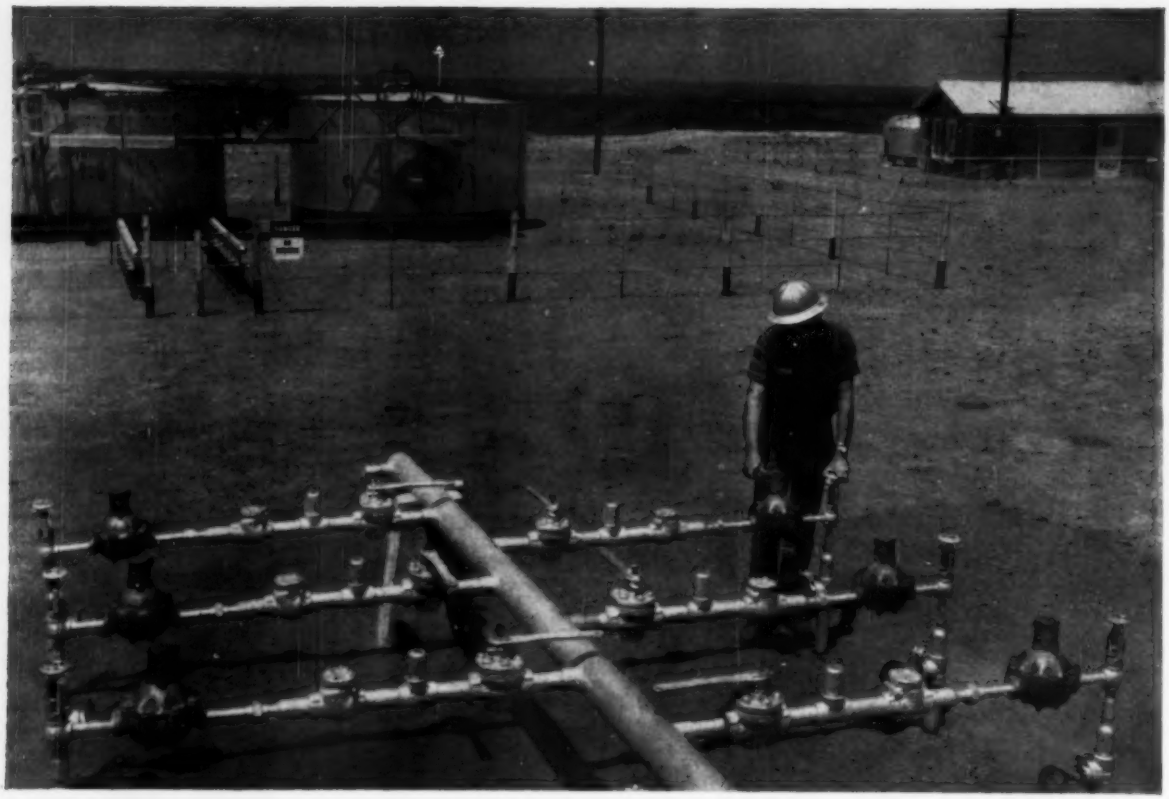

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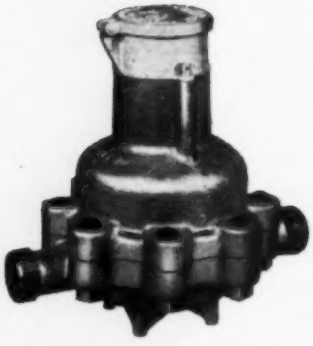

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rock. Four parameters can be set down to define a rock's petrophysical characteristics. Each of these are obtained by direct laboratory measurements on a core. They are all dependent on the pore size distribution of the rock and are, in turn, related to each other. They are,

1. **Permeability, K**
2. **Porosity, ϕ**
3. **Capillary pressure, P_c**
4. **Relative permeability characteristics, K_r**

Permeability and Porosity Relationship

For any given geologic formation with intergranular porosity and permeability, there is a direct relationship between these factors over a specific range of porosity. This is probably true for cavernous and vuggy material if large volumes of rock were considered. This relationship is such, that at a certain lower limit of porosity a formation becomes permeable, and from this point both factors increase in a semi-log manner (a 3 percent increase in porosity usually affords a 10 fold increase in permeability)[1] until an upper limit of porosity for the formation is reached. At this point permeability becomes independent of porosity and may continue to increase while the latter remains constant.

Clean and Dirty Sands

If we were to consider a sandstone formation over the range of the above relationship, we would usually describe it as very shaly, or silty, when it first became permeable. It would continue to be dirty over the range in which porosity is increasing, and become clean when a constant porosity is attained. This characteristic is clearly noted in the less compacted sediments and is almost entirely dependent on the pore size distribution of the rock, which is directly related to the sedimentary conditions under which the rock was laid down — the sorting action, and the degree of compaction.

Kozeny's Equation

An empirical relationship that ties in permeability and porosity with pore size distribution, or more correctly with specific surface area, is known as Kozeny's equation. A correlation based upon Kozeny's work, and expressed by Pirson[2] relates permeability and porosity with the irreducible water saturation. Thus,

$$K = \frac{1}{F}\left(\frac{\phi}{1-\phi}\right)^2 \frac{1}{S_{wi}^2},$$

where F is the Humble formation factor, $0.62^{-2.15}$.

The irreducible water saturation is not only an important value for engineering purposes but also an excellent quantitative expression for the cleanliness or dirtiness of a formation. A plot of this relationship is given in Fig. 1 of the illustration. The 30 percent connate water line is considered, for this discussion, as the dividing line between clean and dirty sands. It can be seen, diagramatically and also by visual observation, that as porosity increases for a given permeability, the sand (or formation) becomes dirtier.

Highly compacted sands, that are still permeable, are usually fairly clean since their dirtier counterparts would quickly become impervious under compaction.

When knowing the average permeability and porosity of a sand, this chart can give a close approximation of its connate water saturation. When porosity is plotted against permeability for a particular sand on this graph, the slope is usually parallel to the iso-connate water lines, but is almost always found below the 30 percent connate water line, since the sand is in a dirty state. Carbonate reservoirs with matrix porosity will usually act as clean sands even in ranges of very low permeabilities. Lower porosities and consequent lower connate waters will be associated with a given permeability for these formations, nevertheless, the relationship shown in Fig. 1 would apply to them.

Capillary Pressure

Capillary pressure characteristics of a rock can be determined in a routine manner almost as readily as its permeability and porosity. As in all core analysis determinations, there are several methods to chose from to obtain the data. The most commonly employed are the restored state method, with several adaptations, and Purcell's[3] mercury imbibition technique.

This rock parameter can be essentially described as the capillary suction exerted by a wetting phase holding it within the interstices of the rock. The basic formula defining the phenomenon is, $P_c = \frac{2\gamma\cos\theta}{r}$, where r is the mean radius of the capillary in which the suction is exerted, and $\gamma\cos\theta$ is the wettability of the fluid.

The actual measurement of this value in the laboratory, however, is achieved by directly displacing the water, or brine, in a saturated sample with air, or oil, and observing its changes in fluid composition for each increment of pressure (restores state method); or, by forcing mercury into an evacuated sample and measuring the quantity imbibed for each pressure change, as in Purcell's method.

From a practical standpoint, capillary pressure data has immediate use in defining the productive characteristics of a reservoir, particularly so, when transition zones are encountered. As shown in the center of the illustration, we have taken as an example a hypothetical oil reservoir which has an average permeability of 80 millidarcies and a porosity of 27 percent. This would be considered a dirty sand when observing our relationship in Fig. 1. The average capillary pressure curve for the reservoir, shown as the heavy line in Fig. 3, can be converted from units of capillary pressure to height above the water table by the equation,

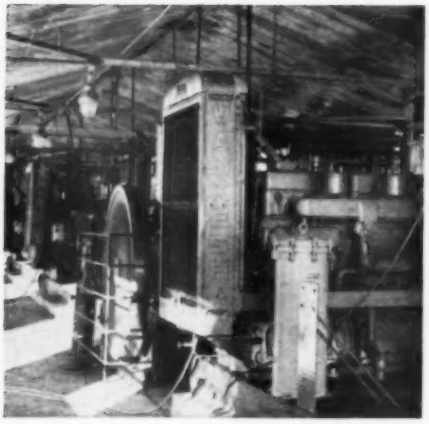
$$H = \frac{P_c - P_d}{g_w - g_o},$$

where P_c is the oil-water capillary pressure, P_d the displacement pressure and $g_w - g_o$ the difference in the oil and water gradients. This curve, then, graphically illustrates how the oil and water saturation is distributed in a virgin reservoir in relation to the height above the free water table, if the rock be treated as homogeneous entity. Gravity and capillary pressure, which must balance when the reservoir is in equilibrium, are the forces which determine this distribution, the latter being governed by the pore size distribution of the rock.

The shape of the curve reflects the lithological properties of the rock. Unconsolidated sands, and well sorted, compacted sands will yield long, flat plateaus. Dirty sands and most of the highly compacted formations will normally exhibit shorter plateaus and sharper rises in the curve. The height of the plateau above the base line is governed by the size of the large pore openings, and the final assymtoptic reading of the curve at high capillary pressures, referred to as the irreducible water saturation, is dependent upon the number of very small grains in the rock.

Pore Size Distribution

The capillary pressure curves are in effect a direct measure of the pore size distribution in the rock. This is par-



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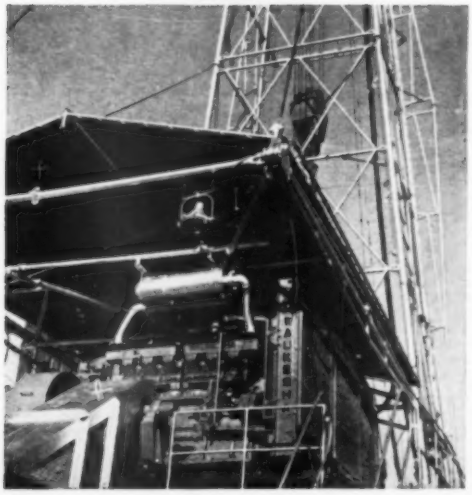
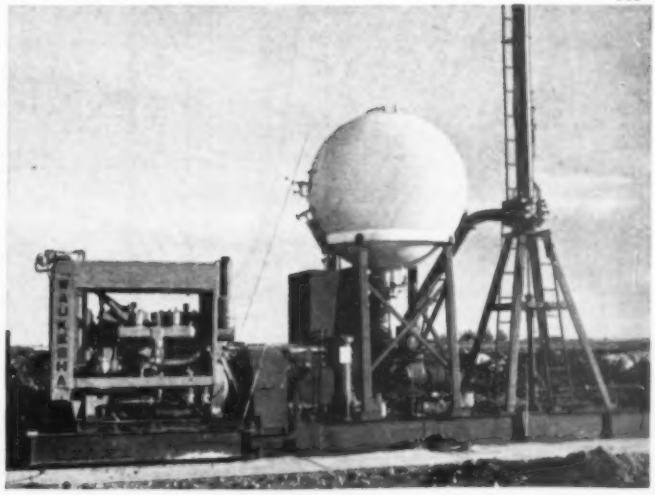




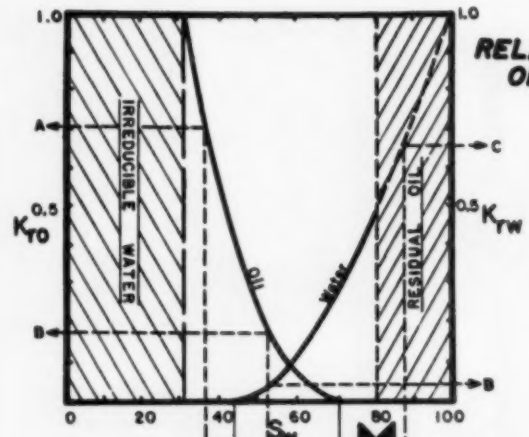


FIG. 4

RELATIVE PERMEABILITY OIL & WATER – K_{ro} & K_{rw}

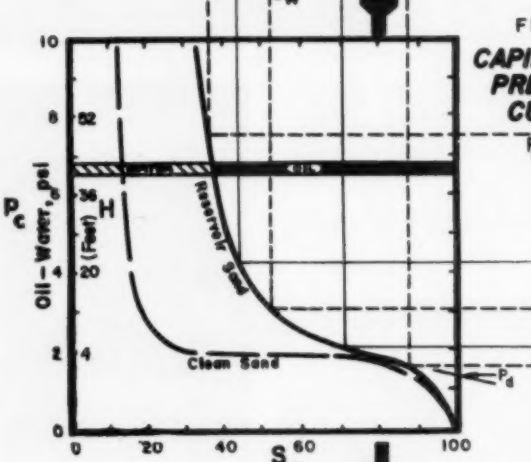
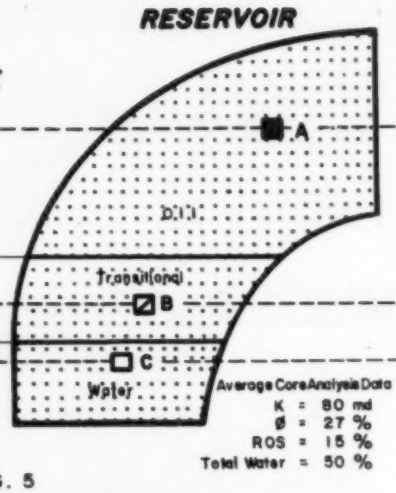


FIG. 3

CAPILLARY PRESSURE CURVE



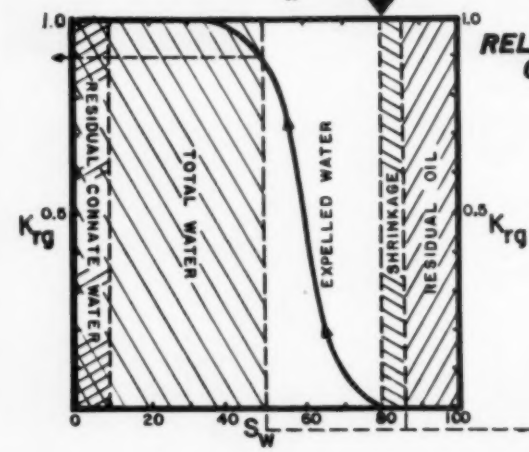


FIG. 5

RELATIVE PERMEABILITY GAS – K_{rg}

FIG. 1

PERM. – POROSITY RELATIONSHIP

SHOWING CLEAN AND DIRTY SANDS

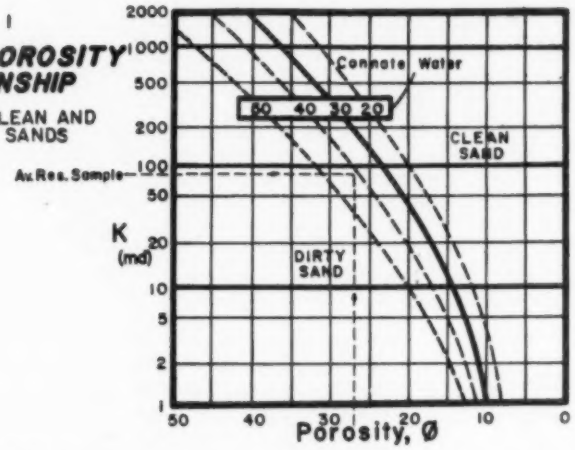


FIG. 2

PORE SIZE DISTRIBUTION

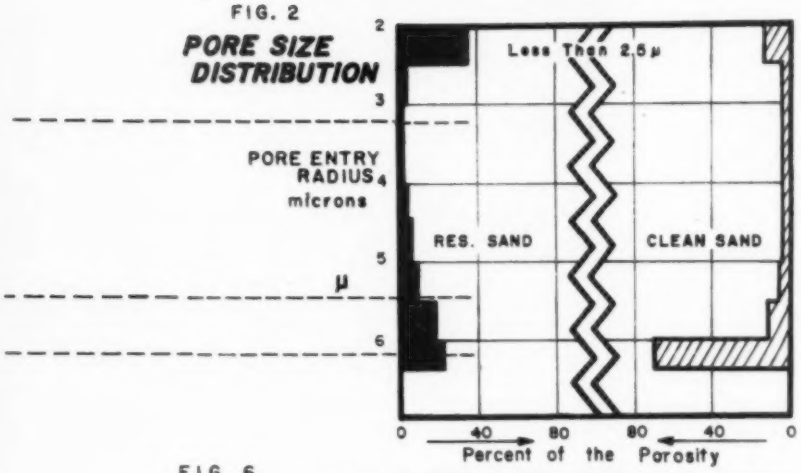
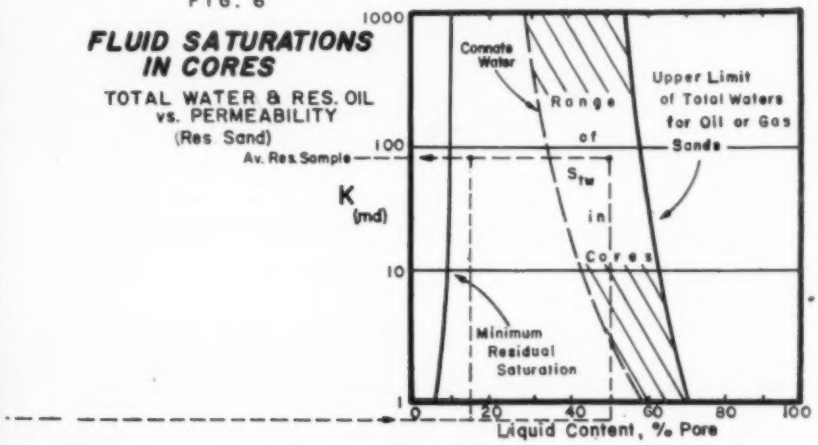


FIG. 6

FLUID SATURATIONS IN CORES

TOTAL WATER & RES. OIL vs. PERMEABILITY (Res Sand)



CORE ANALYSIS AND SOME RESERVOIR ROCK CHARACTERISTICS

PORE SIZE DISTRIBUTION

Permeability, porosity, capillary pressure and relative permeability characteristics are all dependent on pore size distribution of rock.

Dirty formations are those considered to have very irregular grain size distribution.

Clean formations have regular grain size, less smaller grains, better sorting. Pore size distribution can be calculated from capillary pressure curve.

PERMEABILITY — POROSITY

K and ϕ are direct functions of each other when a sand is in a dirty state. A 3% increase in porosity usually produces a 10-fold increase in permeability. K is independent of ϕ in clean state.

As ϕ increases at a given K a formation becomes dirtier.

CAPILLARY PRESSURE CURVE

Length of plateau dependent on cleanliness of sand and degree of compaction. Height of plateau dependent on pore size of rock.

Irreducible water value dependent on number of smaller grains in rock.

RELATIVE K — OIL AND WATER

Dependent first on pore structure and secondly on fluid properties.

Curves usually have configuration shown, with K_{ro} & K_{rw} crossing close to abscissa. K_{ro} usually approaches 1.0 at irreducible water, and K_{rw} close to 0.5 at residual oil.

RELATIVE K — GAS, CORE ANALYSIS

Flushing of formation cores follows relative K line to water until residual oil sat. reached.

After flushing, gas expansion action follows the relative permeability to gas line, expelling water while residual oil shrinks.

K_{rg} curve dependent mostly on pore structure.

FLUID SATURATIONS IN CORES

Variations in fluid content due to differences in flushing action and changes in rock structure.

An upper limit of total water content and a minimum residual oil saturation are usually constant with permeability for a given productive horizon.

ticularly noted in the mercury imbibition method where high capillary pressures are readily achieved. As we see from the capillary pressure equation given earlier, P_c is a function of the mean capillary radius. Since we determine P_c and its corresponding fluid saturations by direct measurement, we should then be able to calculate the mean entry radius of a pore if we knew the value of the wettability function. This has been done by Burdine[4] and others, and the radius equation becomes,

$$r = \frac{\text{Constant}}{P_c}$$

The ordinate of the capillary pressure chart can now be converted to pore entry radius, usually in microns, and a pore size distribution diagram made, as shown in Fig. 2. This shows in what manner the porosity is made up of different radii openings. It, too, can be correlated with height above the water table as in the case of capillary pressure. Fig. 2 shows the pore size distribution for the reservoir example as well as a typical clean sand, which corresponds to the two curves on the capillary pressure chart.

Relative Permeability

This characteristic of the rock is often thought of as being entirely dependent on the other petrophysical parameters mentioned, and, therefore, considered of little additional benefit to further delineate the rock's qualities. Since this is another property that can be ascertained by direct measurements on cores, and in the writer's opinion frequently has its own distinctive features, it is treated as another identifying parameter. When referring to relative permeability, the fluids in question must also be mentioned.

In a virgin oil reservoir the relative permeabilities of first concern are the relative permeabilities to oil and water, K_{ro} and K_{rw}. These govern whether water-free production can be accomplished. The general configuration of the curves are usually found as shown in Fig. 4. The K_{ro} and K_{rw} curves cross close to the abscissa and are frequently very steep in slope indicating that a formation can abruptly go to high water cuts with relatively small changes in reservoir saturations. The relative permeability to oil usually approaches 1.0 as the connate water saturation is reached, while the relative permeability to water is in the range of 0.5 at the final residual oil saturation.

Examples of Predicted Initial Reservoir Performance

To demonstrate how the capillary pressure and relative permeability curves effect the initial performance of a reservoir, three points have been taken, as illustrated, in the hypothetical reservoir.

At point A, approximately 45 ft above the free water table, the connate water saturation for the reservoir is 38 percent. The relative permeability corresponding to this saturation is 0.7, or 70 percent of the specific permeability would be utilized for oil flow. There is no permeability to water at this point. In observing the pore size distribution chart it can be seen that oil has penetrated into the capillary openings 3.25 microns in radius.

At point B, approximately 12 ft above the free water table, the capillary pressure curve indicates a water saturation of 53 percent. The relative permeability relationship reveals that at this saturation the formation is both permeable to oil and water. Therefore, it would be considered in a transitional zone. The relative permeability to oil is slightly higher than that to water, but both have low effective permeabilities because of mutual interference to flow. The pore size distribution chart indicates that oil has only penetrated the pores of 5.5 microns entry radius and larger.

The extent of the transitional zone can be defined by projecting the zero points of the relative permeability curves down to the capillary pressure curve, and reading the differences in height between these points, as shown in the illustration—the lower point, where the permeability to oil is zero, being the oil-water contact.

Point C is below the water table and indicates only permeability to water, however, since it is above the displacement pressure of the sand, P_d, a small residual oil saturation may be present in the larger pores.

Core Analysis

The petrophysical parameters discussed above, that determine so much the productive performance of a reservoir, are in actuality direct core analysis measurements. Moreover, these qualities strongly reflect themselves in the conventional core analysis data usually ascribed to flushed cores taken directly from a formation. Permeabilities and porosities are routine determinations on such (fresh) cores, and the fluid measurements, total waters and residual oil contents, are used as indices to predict probable production.

Flushing and gas expansion action that a core undergoes can be readily explained by the graphs given in the illustration. As an example, if we were to core point A in the reservoir—its original saturations are 38 percent water and 62 percent oil—as the water front encroaches in the core, the oil saturation is decreased until a permeability to water is attained, and at this point the flushing action follows the relative permeability to water line. This process continues until a (final) residual oil saturation is reached. Probably

The Author

Ben A. Elmdahl *owns Ben A. Elmdahl Engineering Company of Houston, Texas, a company specializing in core analysis and mud logging work. Prior to forming his company in 1955, he was district manager of Core Laboratories, Inc. in Houston. He was born in Stockholm, Sweden, and came to the U. S. at the age of 4 and settled in Montclair, New Jersey. He graduated from M.I.T. in 1942 with a BS in chemical engineering.*

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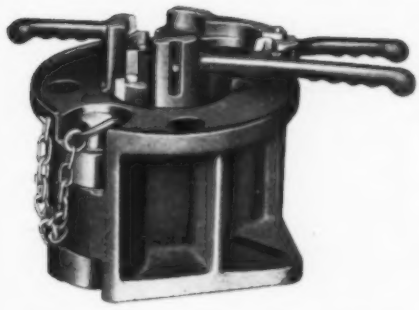

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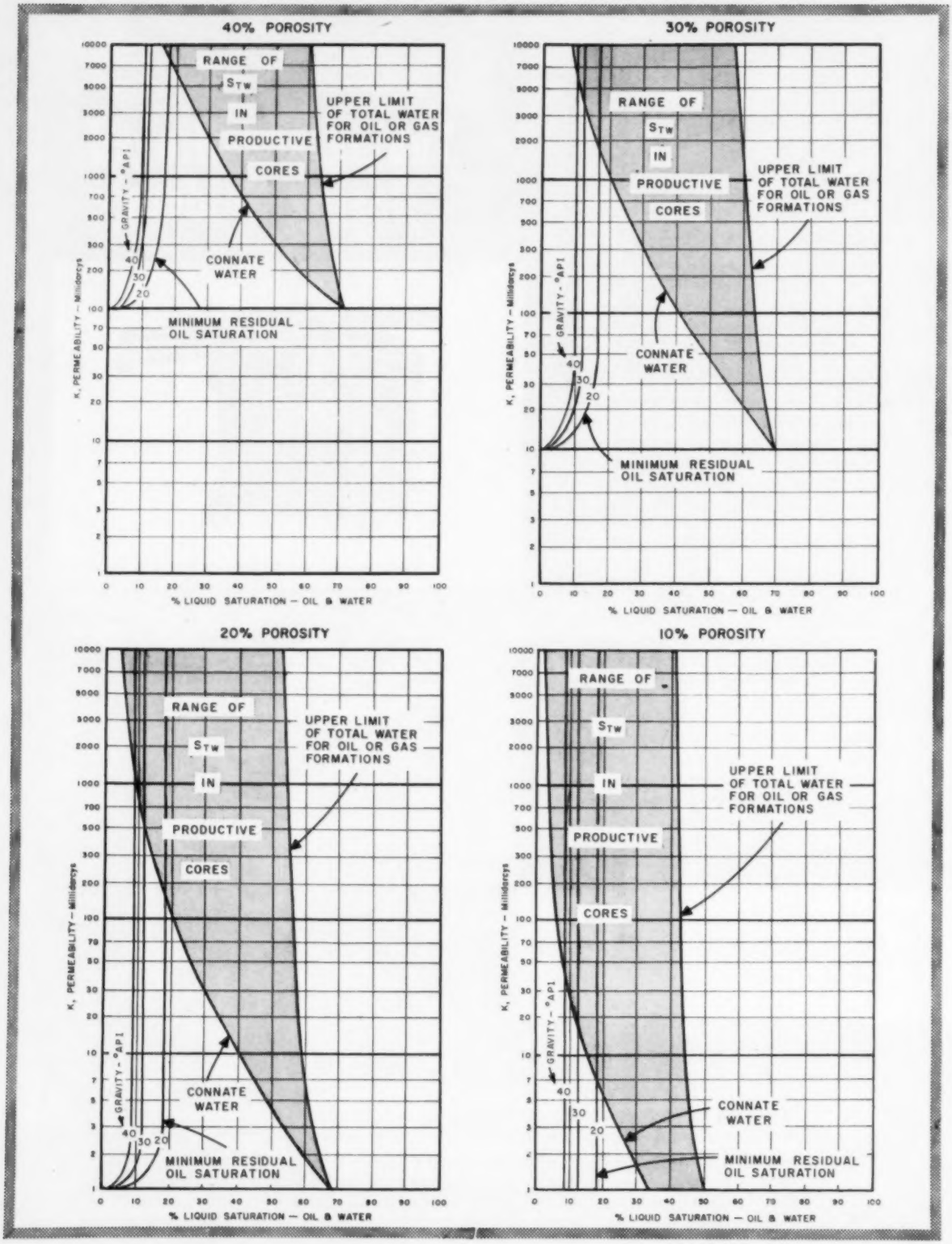
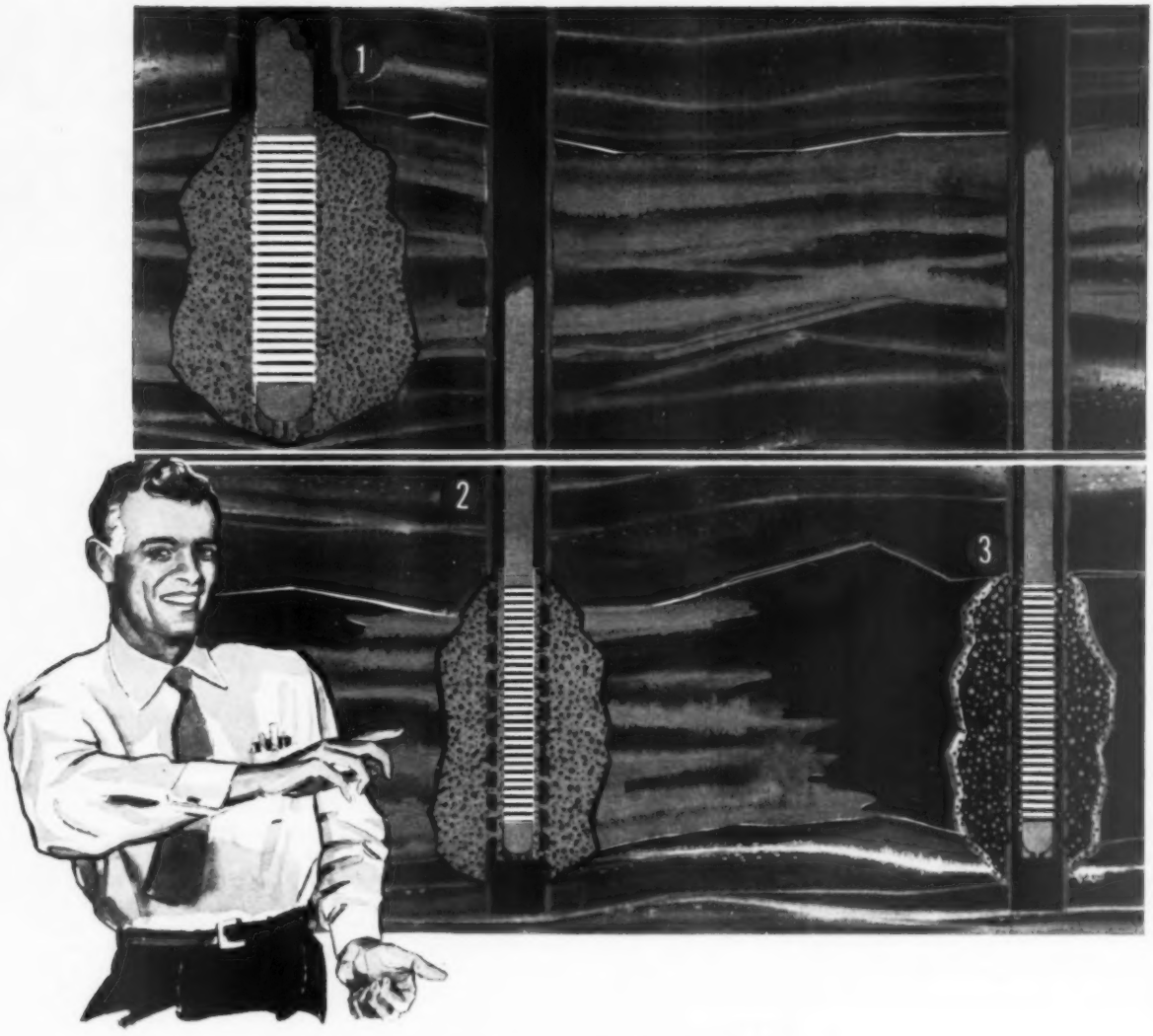
INTERPRETATIVE GRAPHS FOR CORE ANALYSIS DATA

Variations of the Critical Limits of Fluid Contents in Flushed Cores (Total Waters and Residual Oils) with Permeability and Porosity of Formation.





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two or three pore volumes of flushing would achieve this end, and additional flushing action would not substantially reduce the residual oil saturation any further. At this point the relative permeability to water is approximately 0.5, as shown in Fig. 4.

This flushing action is thought analogous to the water encroachment in a water drive reservoir and the final residual oil saturations are considered by many as comparable. In this process, it is most probable that the flushed out oil is removed from the larger pores of the formation, while the intermediate interstices retain the residual oil that is noted in the cores and by-passed in a water drive. It is interesting to note, that if this be the explanation of the flushing phenomenon, there would be a disturbance in the capillary forces of the rock after flushing, tending to make the residual oil subsequently move from the smaller to the larger pores.

After the core is cut and completely flushed its fluid contents would be, for our example, 20 percent oil and 80 percent water. It now undergoes gas expansion action as it is removed from the reservoir to the surface. Fig. 5 illustrates this change where the relative permeability curve shown is typical of a gas liquid relationship. In the case of a flushed core the expanding gas (from the residual oil) expells the encroached water until the K_{rg} value approaches 1.0. This usually occurs at approximately 35 percent gas saturation for consolidated sands. The hypothetical example shows the final fluid saturations in the core as, 15 percent oil, 50 percent total water and 35 percent gas which are, more or less, universal values for a completely flushed, clean oil sand.

If point B were to be cored in the transitional zone of our hypothetical reservoir, it would be found that there isn't sufficient oil in the intermediate interstices of the rock to maintain an appreciable residual oil saturation in the core after flushing. It would probably only be on the order of magnitude of 7 to 8 percent, instead of the 20 percent for the water-free sand. This, in turn, would shrink under expansion to maybe 5 percent. The expanding gas would now only reduce the water saturation to a minimum of 60 percent, assuming there is sufficient gas in the remaining oil to cause the relative permeability of gas to approach 1.0. In the majority of cases, the water saturation would be higher because of inefficient gas expansion at lower residual oils, and the sample would be interpreted as water productive or in a transitional phase. This same reasoning would apply to gas formations as well as oil, and to carbonate rocks as well as sandstones; the figures would vary from formation to formation, however.

Fluid saturations measured in routine core analysis on productive samples from a given geological horizon usually exhibit definite upper limits of total water contents and minimum values of residual oil saturations for constant permeabilities. These values will vary dependent on changes in flushing, but the critical limits can be defined, and on this basis the fluid saturations are used as indices to predict probable production. This relationship is illustrated in Fig. 6 for the hypothetical sand in question.

Interpretive Graphs for Core Analysis Data

Since the residual fluid saturations in flushed cores are very much governed by the pore size distribution of the rock and this characteristic, in turn, is expressed by the permeability and porosity parameters, a relationship between these values can be attained.

At a constant porosity the pore size distribution of a rock would vary with permeability, and, similarly, the critical values of residual oil saturation and total water content would change with this variation in permeability. Graphs showing such a relationship, based upon empirical calculations, have been made for constant porosity values and are given in the illustration. Porosities of 10, 20, 30 and 40 percent are shown. Data for intermediate porosity values can be obtained by interpolating between charts.

Example I: As an example, if a reservoir has average core analysis data as follows:

$K = 50$, $\phi = 20$, $S_o = 20$, $S_{tw} = 50$, it would be observed from the 20 percent graph that the total water content falls well within the range required for production (26-57 percent) and that the residual oil value is sufficiently high even for a low gravity, 20 deg API oil.

Example II: Now if only the porosity were to be changed and dropped to 10 percent, it could be seen from the 10 percent plot that the total water value is above the upper limit necessary for production (43 percent) and the formation is probably water productive.

Example III: If the porosity value were changed, however, to 30 percent, we would again be within the limits required for oil production, with the total water content almost of the same magnitude as the connate water, 48 percent. If, on the other hand, the porosity had been 40 percent with the other data remaining constant, the 40 percent porosity plot would show the permeability below the minimum required for oil accumulation. It would be unlikely that such data could be obtained since the capillary forces at 50 millidarcies and 40 percent porosity would be too great to permit oil to accumulate.

Conclusions

The four petrophysical parameters outlined, permeability, porosity, capillary pressure, and relative permeability are direct core analysis measurements that quantitatively express a rock's producing characteristics. They are dependent on the pore size distribution of the rock, but do not necessarily define the rock type, since common pore size distributions may be associated with entirely different sediments.

The permeability-porosity relationship gives a first-hand indication of the producing properties of a rock. High porosities with relatively low permeabilities would indicate small pores and high capillary attraction. Conversely, low porosities with high permeabilities would indicate large pores with small capillary forces. The capillary pressure curves would define these forces and indicate the presence of transition zones. With the use of relative permeability data they would delineate the extent of the zones.

The four parameters mentioned explain the fluid contents of flushed cores taken from a reservoir and aids in interpretation of these data. They are the fundamental basis from which further study along core analysis lines can be made. Besides affording invaluable data for engineering calculations, these rock parameters are also measurements that can be used as exploratory tools in evaluating a prospective reservoir.

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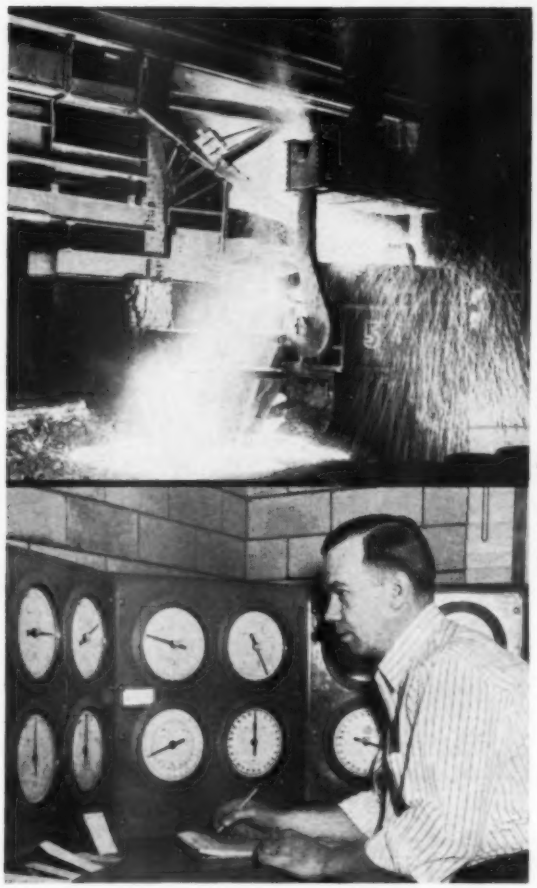

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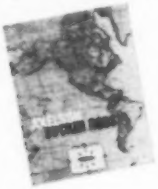

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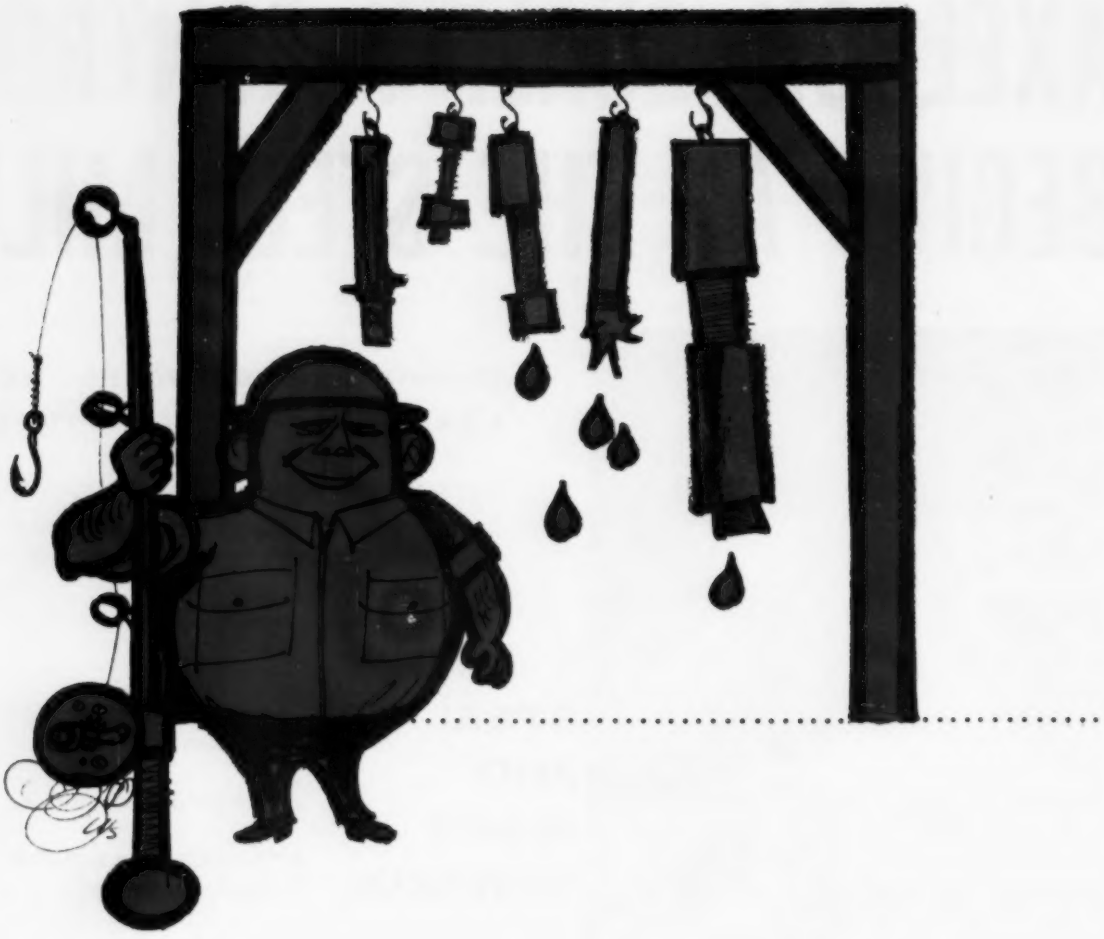

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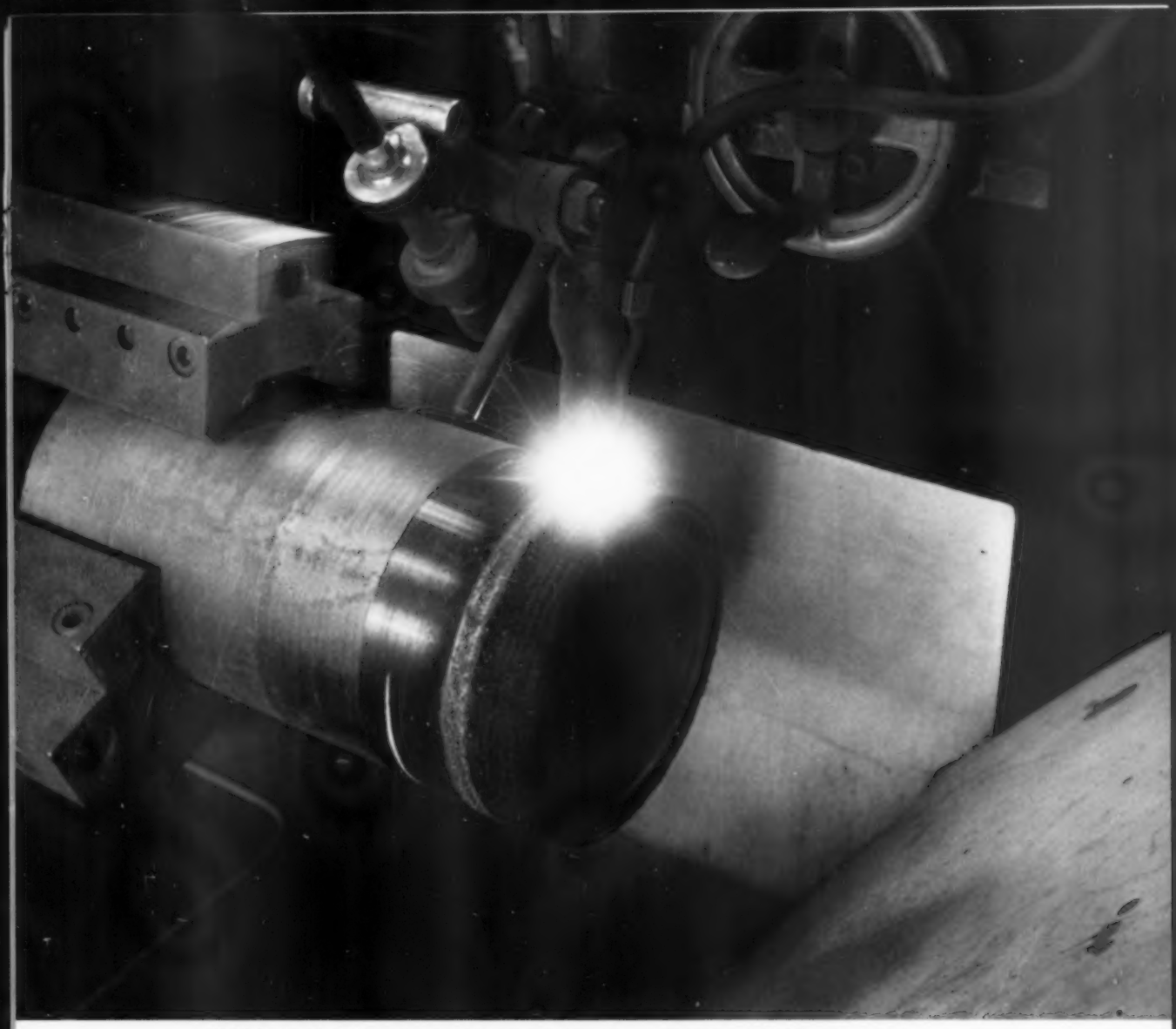

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Rittenhouse New SEPM President

Gordon Rittenhouse, of the Shell Development Company, Houston, Texas, has been elected president of the Society of Economic Paleontologists and Mineralogists. Serving with Rittenhouse on the 1958-59 Council will be R. V. Hollingsworth, Paleontological Laboratory, Midland, Texas, as past president; W. M. Furnish, Iowa State University, Iowa City, Iowa, as vice president; Raymond E. Peck, University of Missouri, Columbia, Missouri, as secretary-treasurer; M. L. Thompson and Charles W. Collinson, State Geological Survey, Urbana, Illinois, as co-editors of the *Journal of Paleontology*, and Jack L. Hough, University of Illinois, Urbana, as editor of the *Journal of Sedimentary Petrology*.

The new SEPM officers assume the responsibility of directing this 1400-member organization at the close of the 32nd annual meeting of the Society, held in Los Angeles, California, March 10-13.

Honorary Members

The Research Committee of SEPM unanimously nominated and the Society's Council has elected three honorary members. They are: Marcus Albert Hanna, chief paleontologist for Gulf Oil Corporation, Houston, Texas. Charles Elijah Decker, of Norman, Oklahoma, and Hans Ernst Thalmann, Stanford University, of Stanford, California. The honorary membership certificates are formally presented at the annual meeting.

Best Paper Awards

Recipients of the awards for the Best Paper in the *Journal of Paleontology* and the *Journal of Sedimentary Petrology* for 1956 have also been announced. They are Mrs. Christina Lockman-Balk, professor of geology at the New Mexico Institute of Mining & Technology, for her paper, "The Evolution of Some Upper Cambrian and Lower Ordovician Trilobite Families," and Maurice A. Carrigy, now with the National Research Council of Alberta, Edmonton, for "Organic Sedimentation in Warnbro Sound, Western Australia."

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Personnel necessary to operate this flood include two pumpers (8 hours per day), a plant operator (24 hours per day), and a gager-meter reader (8 hours per day).

This paper, under the title "Instrumentation and Controls, Centralia Water Flood, Centralia, Illinois," was presented at Petroleum Mechanical Engineering Conference, sponsored by the American Society of Mechanical Engineers, at Tulsa, September 22-25, 1957.

Water Source

Source of water for the Centralia water flood, which it is anticipated will require the injection of a total of 66,000,000 bbl of water before depletion, is the Devonian limestone, at approximately 3000 ft. This formation has been a prolific producer in times past and now produces large quantities of water with small amounts of oil. The produced water was previously disposed of into salt water disposal wells throughout the field. This water contains 47,600 ppm chloride, 60 ppm hydrogen sulfide, 3040 ppm calcium, and 1150 ppm magnesium, is supersaturated with calcium carbonate, and in general is a very corrosive and foul smelling brine. It has no other usable purpose.

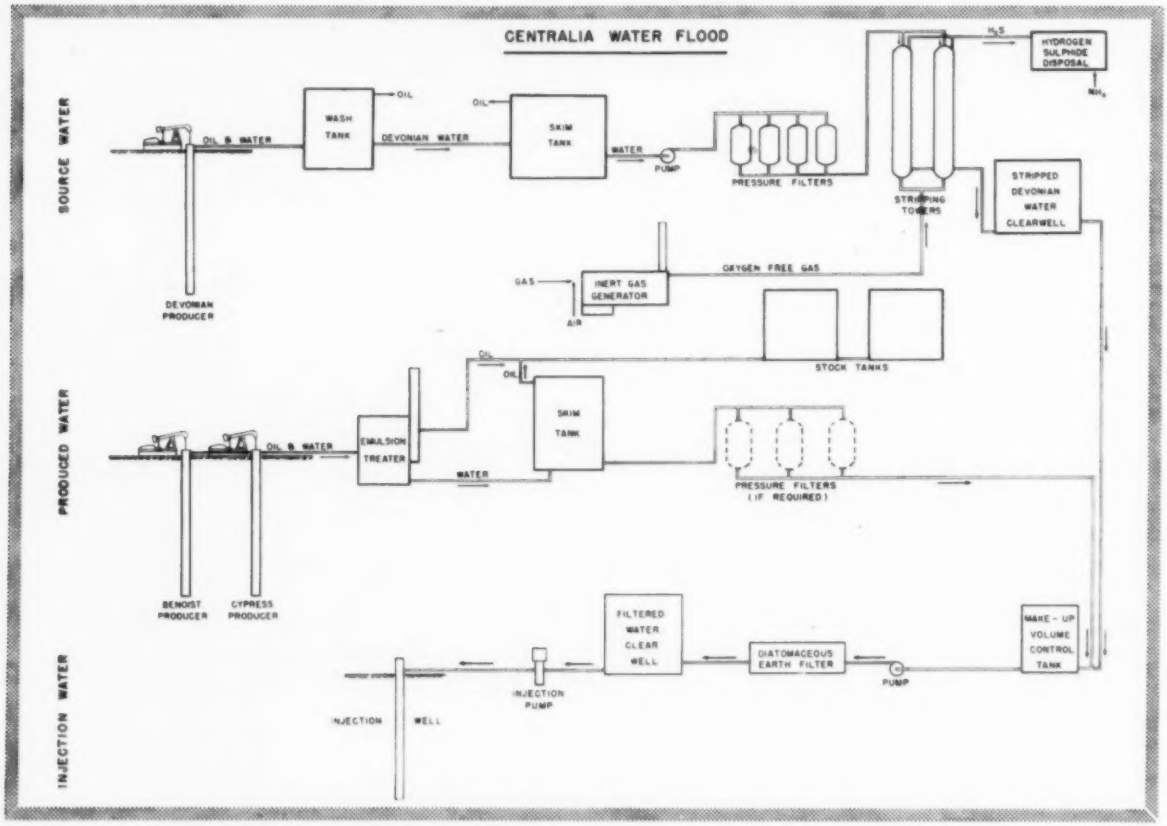
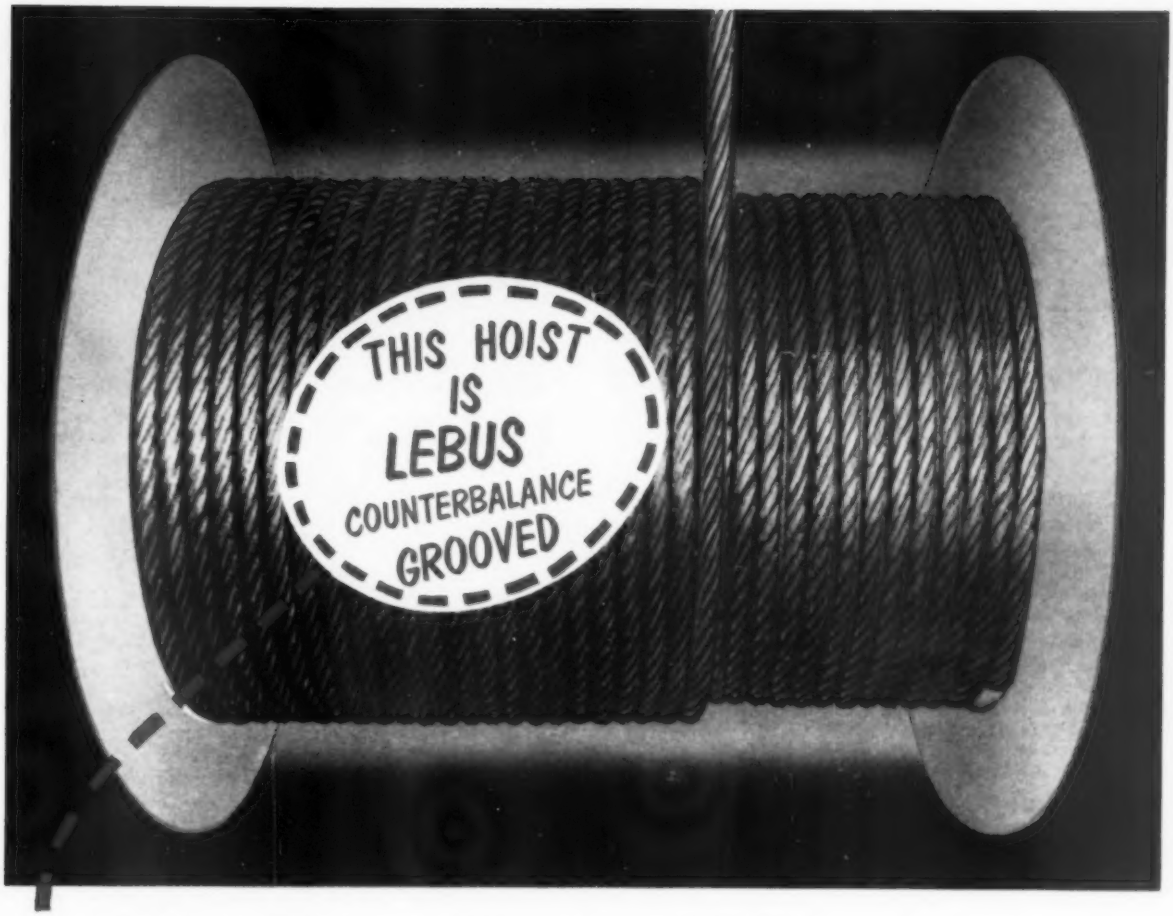


FIG. 1. **Centralia unit's water treating plant** is designed to treat 20,000 bbl of water daily, although present injection rate is about 15,000 bbl per day. A closed type system minimizes oxygen entry into water.



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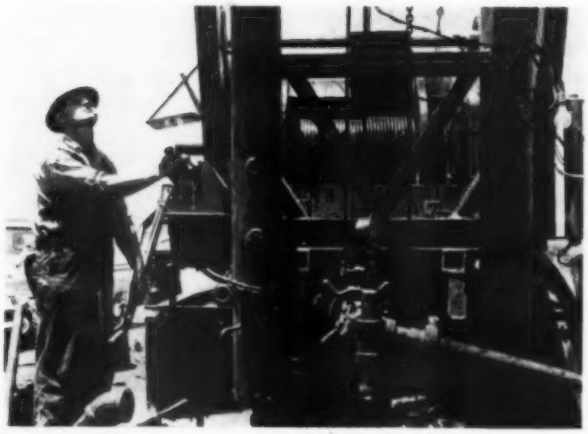

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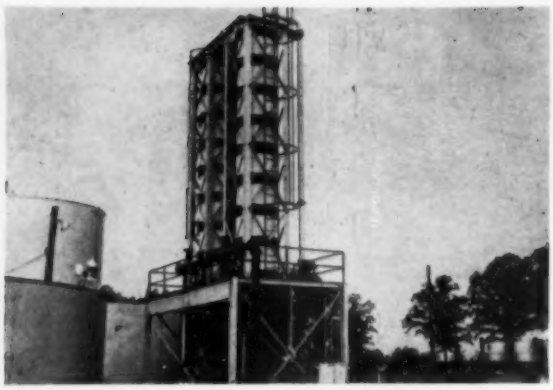

FIG. 2. **Stripping towers,** where hydrogen sulfide is removed, it makes use of inert gas system. Injection water source is the Devonian limestone.

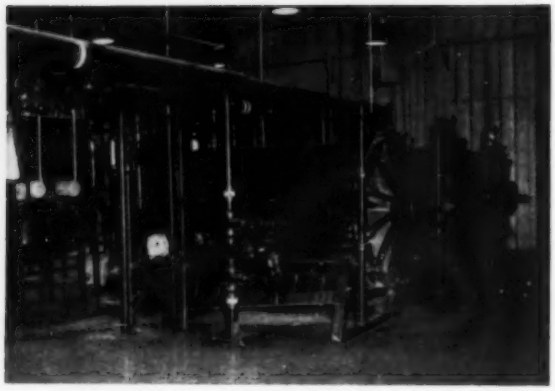

FIG. 3. **Diatomaceous earth filters** put the final polish on injection and recycled produced water. No hydrogen sulfide is present in produced water.

Most of the water used by the Centralia water flood is produced by deep well submersible pumps using conventional switch gear. This water is produced along with small amounts of oil into a large wash tank. A syphon is used to control the water and oil levels. The water then travels approximately one mile by gravity through a 10-in. cement-asbestos pipe to skim tanks at the waterflood treating plant.

Water Treating

The Centralia flood utilizes a closed type treating system to minimize oxygen entry into the water and subsequent corrosion and formation plugging problems. The water treating plant (shown schematically in Fig. 1) is designed to handle approximately 20,000 bbl of water per day although the current recommended injection rate is only 15,000 bbl per day. During the treating process the source water is passed through skim or settling tanks to remove oil and solid particles, anthrafilt filters, to remove additional oil and solids, stripping towers (Fig. 2), where counter current stripping by inert gas removes the hydrogen sulfide gas, and diatomaceous earth filters (Fig. 3) to provide the final polish to the injection water. Produced water also is used for injection but treatment of this water consists only of settling and anthrafilt and diatomaceous earth filtration. No hydrogen sulfide is present in the produced water.

The water treating plant is practically automatic in operation with the treating rate automatically adjusting to the injection rate. All equipment automatically shuts down when it reaches the limit of its variable range, and with the exception of the inert gas genera-

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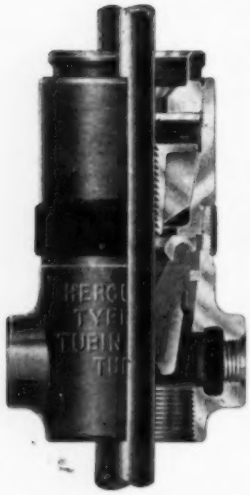

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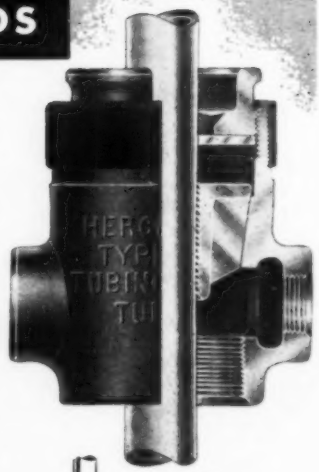

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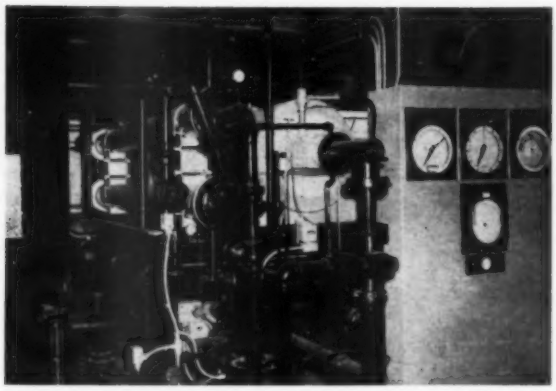

FIG. 4. **Inert gas generators** provide source of the inert gas used to remove hydrogen sulfide from injection water passing through the stripping towers.

FIG. 5. **18 injection headers,** such as this one, take treated and pressured injection water and meters it to the individual wells by high-pressure oscillating disc type meters. Indicating pressure gages for each well also are shown here.

tors and the injection pumps, all automatically restart when conditions require that operations be resumed.

Flow control. Flow through the water treating plant is, in general, flow control by level control. That is, a constant level is maintained in the various tanks in the treating system and the rate is controlled by opening or closing of diaphragm valves on the inlet or outlet of these tanks. Proportional level controllers with displacement type floats control the action of the diaphragm valves. As a secondary means of control, floatless liquid level controllers are located on all tanks to start or stop appropriate pumps should the fluid levels vary from the safe operating range of the displacement type level controls. Floatless level controls also are used to actuate indicating lights and sound alarms in case of unusually high or low levels. Overflow weirs and syphons connected to a waste pit and disposal well are provided for emergency use. Pressure gages throughout the system and the remote recording of the injection pressure assist the plant operator in controlling the flow of water through the plant.

Flow measurement. Flow measurement in the treating plant is accomplished by several types of meters. Incoming source water and produced water are measured by propeller type meters with remote reading rate indicators and totalizers. Flow through the stripping towers is measured by a variable area type meter with a transmitter and remote reading rate recorder, controller and totalizer. Variable area meters are also used to determine the flow rate through each of the diatomaceous earth filters. Differential mercury manometers measure the flow through each of the anthrafilt pressure filters during normal operation and while backwashing. An orifice type meter with a differential converter transmitter and remote reading rate indicator is used to measure the total injection rate.

Water quality control. Quality of the water being injected must be of the highest possible order to insure against premature plugging of the injection wells. Tests are run on the source, produced, and mixed injection waters every eight hours. Suitable instruments are available to permit the following tests:

1. Millipore filter
2. Iron content
3. Oxygen content
4. Hydrogen sulfide content
5. Carbonate saturation
6. pH

Inert gas generators. Hydrogen sulfide is stripped from the Devonian source water by passing the water through ceramic stripping towers against a counter current flow of inert gas. Hydrogen sulfide is removed from the water by mechanical stripping and is carried off by the inert gas. Gas used in this stripping operation is provided by three inert gas generators (Fig. 4) which burn natural gas under carefully controlled conditions. The gas generated has an approximate analysis of 86 percent nitrogen, 12 percent carbon dioxide, 1 percent carbon monoxide and 1 percent hydrogen, and has a volume increase of approximately 9:1 over the amount of natural gas consumed. Absence of oxygen in this gas is essential to the operation and permits hydrogen sulfide stripping without permitting oxygen entry into the injection water, thus eliminating corrosion in the form of iron oxide.

FIG. 6. **Automatic well testing begins** at this production header. The three-way hydramotor valves divert produced fluid into a small heater-treater for oil and water separation, then automatically measured.

FIG. 7. **Well test programming** is done on this unit. The equipment also accumulates and prints well test data. Some 220 truly accurate well tests are obtained each month.

The Author

K. W. Foster *is an electrical engineer in the electrical and control section of Shell Oil Company's technical services division, Houston, Texas. He was graduated from Texas A&M College in 1949 with a BS degree in electrical engineering and in 1950 received a MS degree also from Texas A&M. He joined Shell in September 1950, as a junior engineer, and has held engineering positions in North Texas, Illinois, and Houston. He assisted in the design of the instrumentation and controls at the Centralia Water Flood and was associated with the flood during its installation and first 18 months of operation.*

The inert gas generators are equipped with instruments to measure and record gas flow, carbon dioxide content, and oxygen content. A variable area flow meter measures and records the water flow through the stripping towers and a pneumatic controller adjusts the gas rate accordingly. Indicating thermometers show the temperature of the various cooling waters on the generators and an oscillating disc type meter is used to measure the flow of cooling water. Pressure switches on the cooling water system, the incoming gas line, and the suction and discharge sides of the reciprocating gas compressors actuate lights and alarms to aid in the operation of this equipment and shut down the generators in the event of trouble. Relief valves, control valves, automatic drips, and other pieces of instrumentation make these generators automatic in operation except for start-up.

Injection pumps. Two high-pressure vertical turbine type pumps provide the necessary pressure for the injection water. Each has a capacity of 20,000 bbl per day at approximately 825 psi. These pumps are powered by 350 hp, 3500 rpm squirrel cage induction motors which have outdoor cabinetrol control equipment and are started directly across the line. Controls are provided to shut down the pumps under excess or no flow conditions, when the water level in the clearwell tank falls below a predetermined level and in case of an overload, short circuit or excessive motor bearing temperatures. A pressure controller on the injection line actuates a diaphragm valve so that the pumps are always started against a closed discharge. Circuitry also is provided so that only one pump can be run at a time and a time delay is included so that the pumps will not shut down on momentary power interruptions. Internal electrical heaters are energized whenever a motor is shut down to prevent condensation from forming in the windings.

Injection system. Injection water after being pressurized by the injection pumps flows through a trunk line to 18 injection headers (Fig. 5). At these headers the water is metered to the individual wells by high-pressure oscillating disc type meters. Control of the flow rate to individual wells is accomplished by adjusting a hand operated flow control valve for each well. An indicating pressure gage for each well is also located at these headers.

Production

Producing wells. All 112 producing wells in the water flood are pumped with conventional beam units of various sizes. These units are powered by three phase, 440-v, high starting torque, low starting current, medium slip, squirrel cage induction motors. Motor controls consist of conventional oil field motor controllers with three coil overloads and time delayed restarting.

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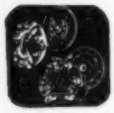
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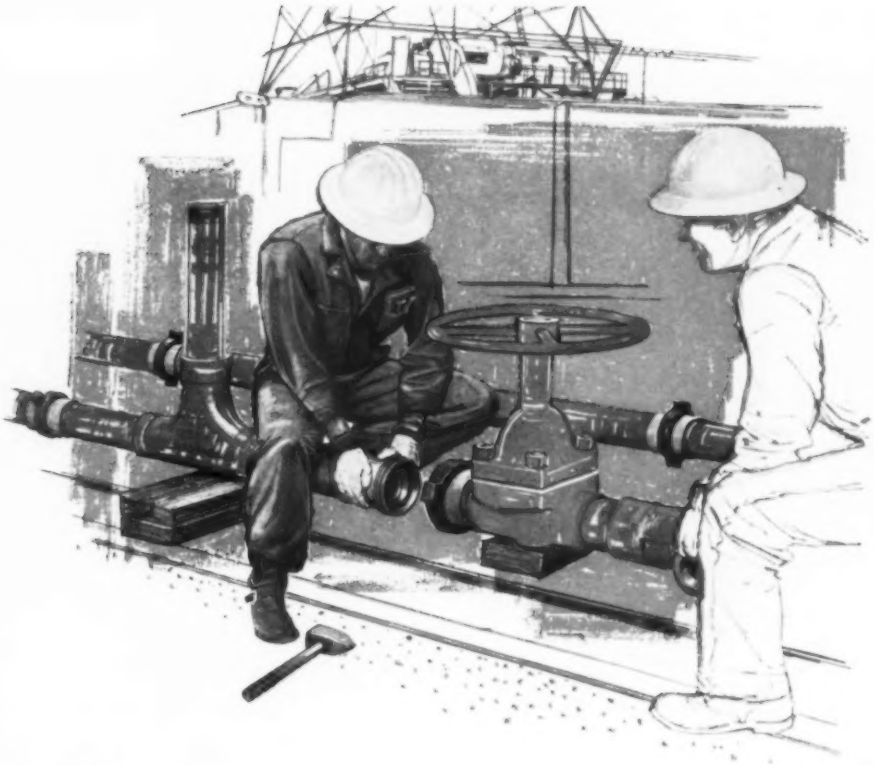

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Automatic well testing. One of the time consuming duties of a pumper in the oil field is obtaining an adequate number of accurate well tests. These well tests are used in numerous engineering calculations and are the basis for many management decisions. In order to obtain the desired number of accurate tests on the 112 producing wells in the Centralia flood with the least operating labor and at a minimum cost, automatic well testing equipment was designed and installed.

Eight well test stations were selected, each serving 10 to 18 wells, depending on terrain, etc., and providing at least one, and in most cases two, 24-hour well tests for each well per month. At each station, the test facilities automatically select the well to be tested, separate with heat and meter the water and oil produced, and record well test results in a printed form. This record includes the date, time, field, well number, and barrels of oil and water to the nearest one-tenth barrel. An additional counter is provided to record gas production if desired.

Automatic well testing begins at the production header shown in Fig. 6, where a three-way hydramotor valve is utilized to divert produced fluid into a small heater-treater where the oil and water are separated. The separated fluids, after accumulating in small tanks at the outlets of the treater, are pumped at an optimum rate through their respective meters. Impulse type registers on the meters cause an electrical contact closure each tenth of a barrel. These contact closures actuate appropriate counters in the recorder. Programming of well tests, accumulating of data, and printing of test results are all accomplished by the well test unit shown in Fig. 7. A schematic diagram of the automatic well testing facilities is shown in Fig. 8. These well test facilities were placed in operation in May 1956, and have operated very satisfactorily. In excess of 220 well tests are consistently obtained each month with an accuracy unobtainable by previously used methods of well testing.

Operations recording. As a further aid to the pumpers in the Centralia unit a 20-point hammer type operations recorder was installed at each of the eight test stations. These operations recorders are actuated by a flow switch in each individual well flow line and make a record of each well's producing time. This record affords the pumper a convenient way of quickly checking the operation of his many producing wells. The operations recorder is shown in Fig. 7.

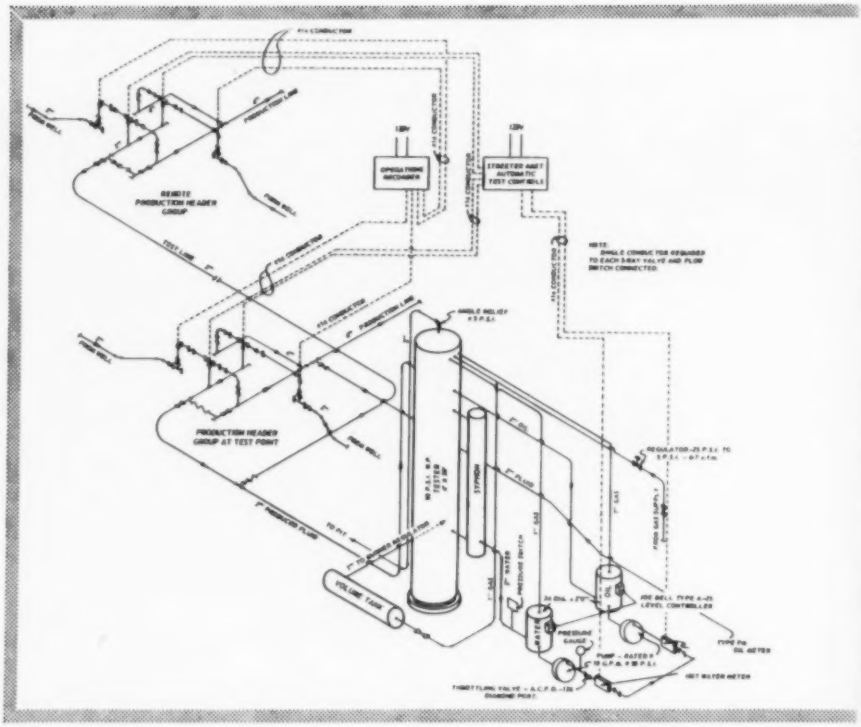


FIG. 8. **Schematic diagram** of automatic well testing facilities outlines operation of well tests and fluid flow.

Oil handling facilities. The produced fluids from all wells in the Centralia unit are conveyed via individual flow lines to production headers and then by a trunk line to the water treating plant site where the oil and water are separated, the oil stored and sold, and the water used for injection.

As the produced fluids enter the treating plant site they pass through a series of heat exchangers where they are preheated by the oil to stock and the inert gas generator cooling water. Produced fluids are then routed to free water knockouts and treaters where the oil and water are separated. Produced water goes to the water treating plant and oil goes to storage by way of the stock oil heat exchanger.

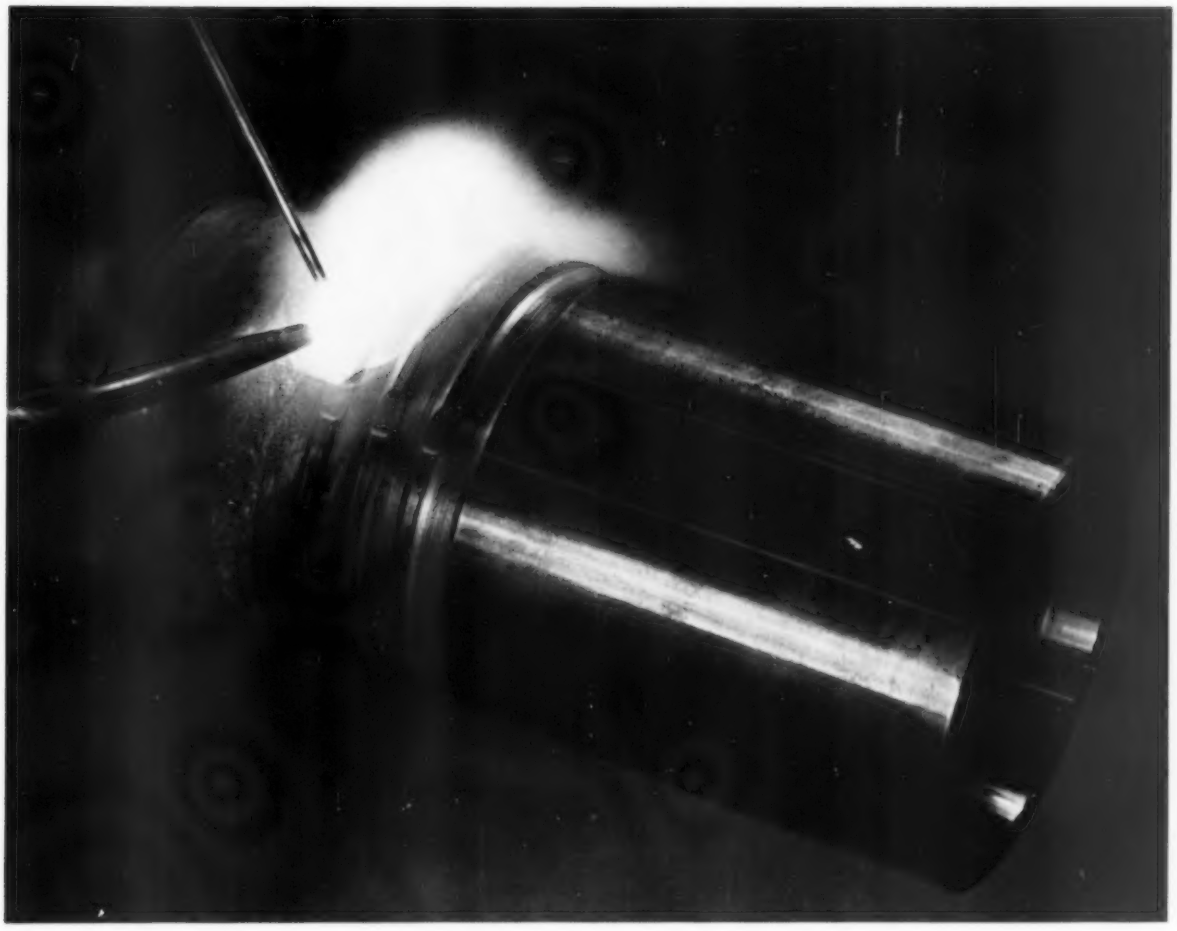
Oil storage at the Centralia flood consists of four 5000-bbl steel tanks equipped with ground level and remote gaging, ground level thiefing, continuous tank temperature recording, and automatic recirculating of tank bottoms. The automatic tank bottom recirculating system for this battery was designed so that as the inlet to each tank is opened for filling, the drain line is automatically opened and the circulating pump is started. Tank bottoms are then circulated through the treating system for one hour. This eliminates bs&w build-up in the bottom of the tanks and the attendant tank cleaning losses and expenses.

Pipeline Pump Station

A portion of oil from the Centralia water flood storage tanks is pumped via Shell-operated pipeline to Sandoval, some six miles distant. Pump station for this pipeline is located approximately one-quarter mile from the water treating plant and to expedite operation of this pump station, remote controls were installed in the waterflood office. These remote controls consist of push-buttons to start or stop either of two electric motor driven pipeline pumps and open or close the discharge valve on storage tanks at the pump station. Indicating lights show operating condition of motors and valves and a pressure recorder records pipeline pressure. Remote gaging of pump station storage tank also is provided. Other control equipment located at the pump station protects pumps and motors from overloads and shuts down the pumps in case of abnormally high or low line pressure or when the storage tanks have emptied.

Operating Personnel

Extensive use of instrumentation and controls for the Centralia water flood has made it possible to operate the 112 producing wells and 97 injection wells with two pumpers and a combination gager-meter man. These men work eight hours a day, seven days a week. Plant operations are handled by one operator on three shifts, seven days a week. * * *



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DEEPER DRILLING TREND SEEN IN AAODC '57 STATISTICS

Drilling time rate holds steady; contract cost drops to $4.60 per ft — lowest in 10 years

AVERAGE WELL DEPTH in the U.S. last year was 4120 ft, reports the American Association of Oilwell Drilling Contractors, reflecting the definite trend to deeper drilling necessary to find new oil reserves.

The average depth was greater in 1957 than in any previous year, announced the association in its annual compilation of drilling statistics. In 1956 the average depth was 4022 ft and was 4044 ft in 1955.

Completions Decline

Total well completions last year showed a 7.9 percent decline from 1956. Last year's total of 53,668 was down 4603 from the 1956 record high of 58,271. Because of the fewer wells drilled, total footage was down more than 13,000,000 ft from the previous year, to 221,112,160.

"For the first time since World War II drilling activity was appreciably below the predicted levels for any given year," Brad Mills, AAODC executive vice president commented in a letter to AAODC members. "This was due to a combination of circumstances, including (1) softening of the general economic picture; (2) lowered consumption of petroleum products, (3) continuation of heavy imports, and (4) increased expenditures on foreign drilling operations.

Drilling Time Steady

Average drilling time (in days) failed to show any decrease from last year's figure. The time, however, is 54 percent of that required to drill similar wells of the same depth in 1941.

Continued operation of older and less efficient rigs by U. S. contractors is cited as a primary reason for this significant failure to improve the average drilling time in 1957. New rig purchases for domestic operations were at a very low level during the year, Mills pointed out.

In previous statements, the AAODC has maintained that the current level of contractor income is generally too

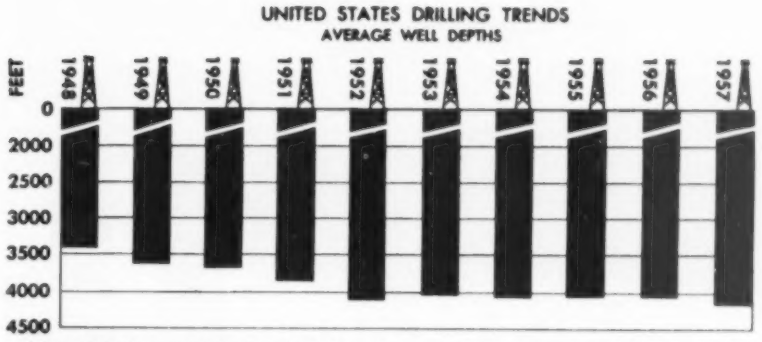

FIG. 1. Drill bits went deeper in '57 to set a new well depth average of 4120 ft. Previous deepest year was in 1952 when the average well depth was 4060 ft.

TABLE 1. Comparison of Drilling Costs.

	1941 ¢	1945 ¢	1947 ¢	1948 ¢	1949 ¢	1950 ¢	1951 ¢	1952 ¢	1953 ¢	1954 ¢	1955 ¢	1956 ¢	1957 ¢
Labor costs	100	140	150	170	180	190	196	197	198	200	202	204	208
Equipment costs	100	110	132	145	160	175	180	183	188	190	195	200	205
Miscellaneous costs	100	120	160	165	170	175	181	185	188	191	194	199	204
Total rotary drilling costs	100	122	145	160	170	180	186	189	192	194	197	201	206
*Drilling prices (footage basis)	100	115	110	105	101	100	103	103	102	99	96	93	90
Average drilling time (days)	100	95	85	80	75	65	60	59	58	56	56	54	54

*For drilling in same or similar fields to comparable depths.
NOTE: "Rate of Penetration" has been dropped because of its close relationship to drilling time in days.

TABLE 2. United States Drilling Trends.

Year	Total new wells completed	Average depth per well	Average contract cost per foot	Average total cost per foot	Total footage drilled	Work by contractors, percent
1935	24,851	2760	5.00	8.00	67,844,939	68
1936	28,962	2797	4.75	7.75	80,996,816	69
1937	35,213	2985	4.50	7.50	105,099,189	71
1938	29,127	3110	4.25	7.50	90,585,158	71
1939	28,012	3053	4.25	7.50	85,523,094	70
1940	31,149	3088	4.00	7.50	96,182,605	71
1941	32,510	3056	4.25	7.25	99,347,714	72
1942	21,990	3088	4.00	7.50	67,903,053	70
1943	20,349	3046	4.50	8.00	61,991,857	75
1944	25,786	3272	4.75	8.25	84,378,457	78
1945	26,649	3489	5.00	9.00	92,982,113	80
1946	30,230	3345	5.00	9.50	101,124,813	81
1947	33,147	3404	5.00	10.25	112,816,124	81
1948	39,477	3463	4.75	10.75	136,709,153	82
1949	38,962	3558	4.75	10.75	138,616,941	85
1950	43,204	3689	5.00	11.00	159,393,997	88
1951	44,196	3869	5.50	11.50	173,315,000	90
1952	45,879	4060	5.85	12.00	186,389,000	91
1953	49,279	4016	5.60	12.50	197,920,000	91
1954	53,650	4025	5.10	12.75	215,940,250	92
1955	56,850	4044	4.90	13.25	229,901,401	92
1956	58,271	4022	4.75	13.50	234,350,550	93
1957*	53,668	4120	4.60	14.00	221,112,160	93

*Estimated.

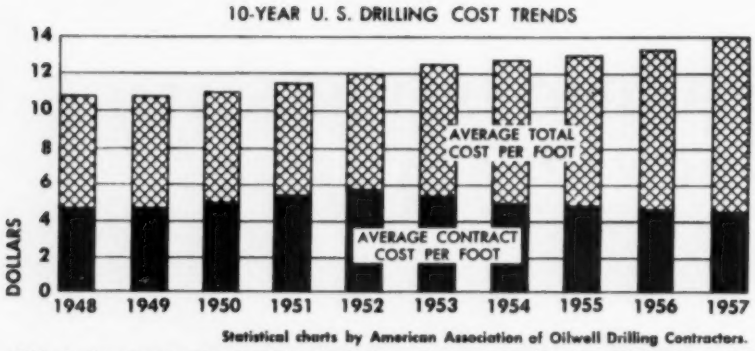

FIG. 2. Average contract cost per foot has dropped steadily since 1952. This cost is becoming a smaller portion of the total well cost per foot. In 1957, the contract cost was $4.60 per ft; the total well cost per foot was $14.00.

low to allow for adequate replacement of equipment as it wears out. Mills pointed out that the statistical summary bears out this conclusion, as the average contract cost per foot fell in 1957 to a 10-year low of $4.60. Total drilling cost per foot, which includes materials and services in addition to that provided by the contractor, rose to an all-time high of $14.

Costs Cut Deeper

"Contractor charges to the operator are only 32.8 percent of the total costs of drilling," Mills explained. "The rise in total costs is due to increases in the prices of steel goods of all kinds, transportation, materials, labor and other charges paid directly by the operator."

The statistical summaries showed that contractors continued to drill most U. S. wells, an indicated 93 percent. Contractor-drilled footage amounted to 205,634,309, with 49,911 well completions.

The AAODC tabulations are based on weighted averages of figures obtained by a national survey of operators and contractors. Price comparisons are based on drilling in same or similar fields to comparable depths, and are not intended to indicate a prevailing price structure in any given area.

The Future?

"The year 1958 offers problems that make it extremely difficult to forecast activity for this period," Mills observed. "However, if we are to maintain adequate reserves for the future, a drilling program somewhat comparable to that of the past few years must be carried out." ★ ★ ★

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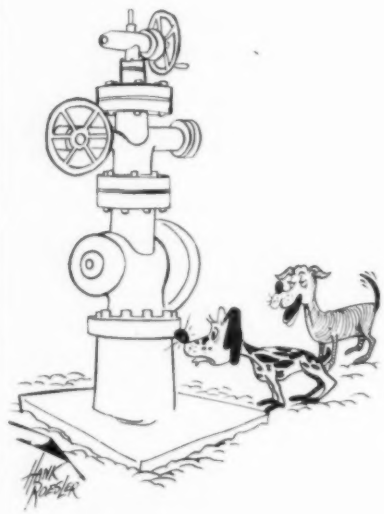

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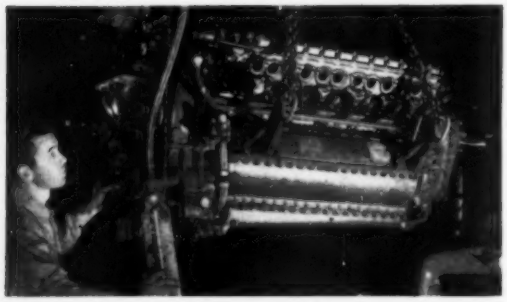
DOWELL RECENTLY PERFORMED THIS RECORD-BREAKING HIGH-INJECTION-RATE TREATMENT AVERAGING



IN ALL AREAS now, powerful, remote-controlled Allison-powered pumpers are available to make high-injection-rate fracturing economical. This mighty aircraft engine, heart of the pumping unit, has a maximum rating of 1500 horsepower and delivers 600 hydraulic horsepower from Dowell's high volume pumps.

HIGH-INJECTION-RATE FRACTURING BY

Many operators are going to high-injection-rate fracturing for one simple reason. It gives them more oil for their money!

At first this may seem strange. More equipment is required for the treatment. The tubing string may have to be pulled.

When all factors are taken into consideration, the cost per job is considerably higher—but the results are often startlingly better.

Many wells that do not respond well to fracturing down tubing show excellent results when tubing is pulled and injection rates are increased. The graph on the next page is an example of this fact as proved in one producing field.

To help make high-injection-rate fracturing practical, Dowell

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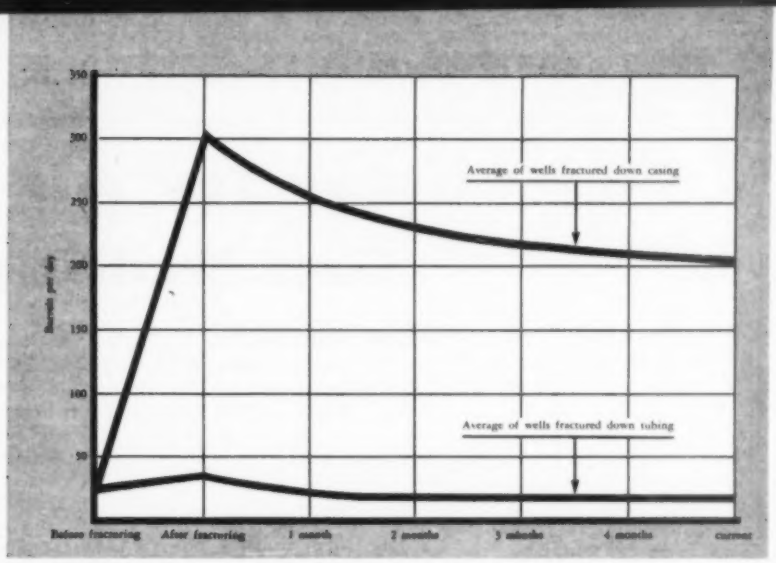

IN YOAKUM COUNTY, WEST TEXAS, a study was made by oil company engineers, comparing the results of high-injection-rate fracturing down casing with low-injection-rate fracturing down tubing. This study showed that casing jobs yielded far better results. The average initial increase was over 12 times as great. More important, however, production held up far better as shown on the graph.

NEAR SHREVEPORT, LOUISIANA, as well as other areas, some operators use Fixafrac® or ball sealers to improve the effects of high-injection-rate fracturing. Temporary plugging materials help spread the force of the treatment over the entire face of the pay for better results.

DOWELL-FOR GOOD ULTIMATE RECOVERY

developed the remote-controlled pumper powered by an Allison aircraft engine. This is still the most powerful unit—pound for pound—in general use.

Take advantage of the experience Dowell has accumulated in this service. For full information on the advantages of high-injection-rate fracturing, call any of the 165 Dowell service points in the United States and Canada; in Venezuela, contact United Oilwell Service. Dowell Incorporated, Tulsa 1, Oklahoma.

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PULLING TUBING can be one of the greatest aids to high-injection-rate fracturing. Many operators have found that the cost of pulling tubing amounts to only a small per cent of the total cost of fracturing. Yet, the production increase sometimes is more than twice as great.

draulic horsepower from Dowell's high volume pumps.

To help make high-injection-rate fracturing practical, Dowell

Charts for Air and Gas Drilling

Experience to date in air and gas drilling operations indicates that drilling efficiency is dependent to a considerable degree upon the circulation system. In essence annular velocities must be maintained sufficiently high to remove cuttings and the design of drilling strings must be such as to reduce pressure losses in the system.

The following has been compiled to assist in approximating the volumes of air or gas required and bottom-hole pressures. To further simplify this work the problem is divided into its two components; (1) the determination of volume requirements and (2) determination of pressure loss.

Volume Requirements

Charts 1, 2 and 3 have been prepared by K. M. Nicolson of the Standard Oil Company of California for use in estimating bottom-hole pressure and volume requirements. Further discussion of this subject may be obtained in his article "Air and Gas Drilling" published in June 1954, page B-107 in THE PETROLEUM ENGINEER. The subject charts are based upon the thermodynamic properties of gas and air and upon the equation:

$$V = 2.67 \frac{(dP_p)\ ½}{(P_f)}$$

where

V = Velocity of lifting fluid
d = Diameter of particle
P_p = Density of particle
P_f = Density of fluid

Example of use of charts 1, 2, and 3:

Example. Assume the following: Depth of hole 4000 ft, hole size 6¼-in., drill-pipe sizes 3½-in., temperature at bottom hole 120 deg. Find volume of free gas required to lift ¼-in. particle.

Step 1. Refer to Table 1 to determine the equivalent diameter to depth ratio, D/L, which for 6¼-in. hole, 3½-in. drill pipe and 4000 ft hole depths is 0.58×10^{-4}.

TABLE 1. Equivalent diameter to depth ratio, D/L $\times 10^{-4}$

Hole D_h size	4¼"	6¼"	10⅝"	10⅝"	10⅝"	12¼"	12¼"
Pipe D_p size	2⅜"	3½"	3½"	4½"	6⅝"	4½"	6⅝"
Depth:							
500	3.1	4.6	11.8	10.2	6.7	12.9	9.4
1000	1.6	2.3	5.9	5.1	3.3	6.5	4.7
2000	0.79	1.2	3.0	2.6	1.7	3.2	2.3
3000	0.52	0.77	2.0	1.7	1.1	2.2	1.6
4000	0.39	0.58	1.5	1.3	0.83	1.6	1.2
5000	0.31	0.46	1.2	1.0	0.67	1.3	0.94
6000	0.26	0.38	0.98	0.85	0.56	1.1	0.78

Basis: Hydraulic radius of annulus $= \frac{(D_h - D_p)}{4}$

Equivalent diameter of the annulus, $D = D_h - D_p$

Step 2. On Chart 2 enter chart at ¼-in. particle size, find intersection with D/L ratio of 0.58 and read bottom-hole pressure of 145 psia.

Step 3. On Chart 2 enter at gas pressure of 145 psia, find intersection with bottom-hole temperature of 120 deg, project to intersection with ¼-in. particle diameter. *Note:* Density of gas under these conditions of 0.46

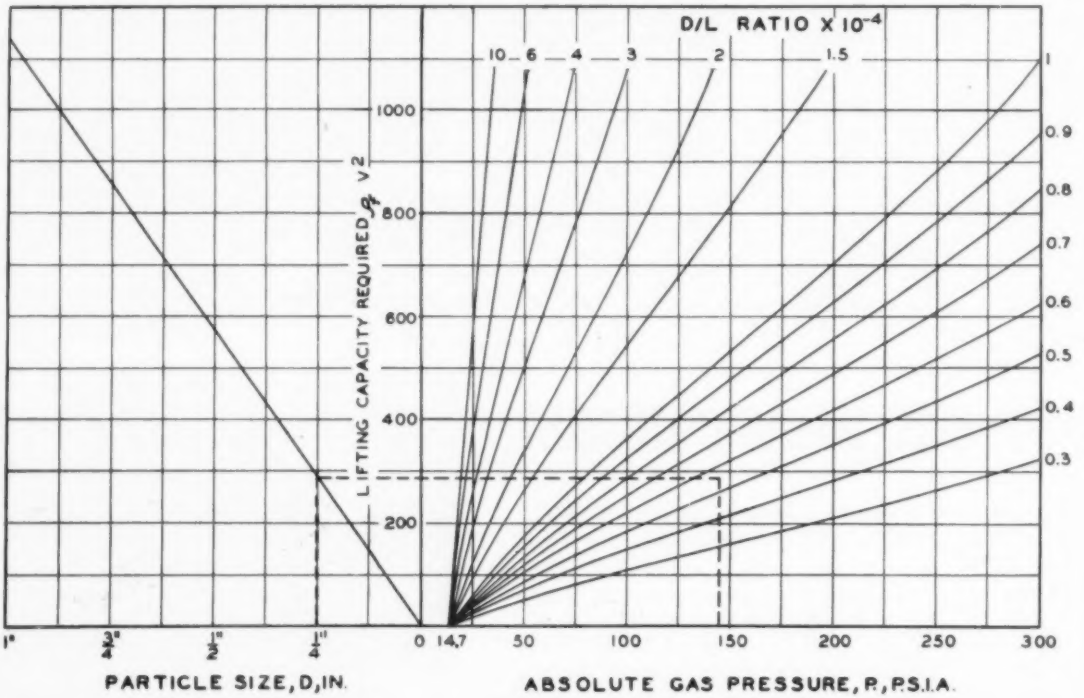

CHART 1.

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as great.

lb per cu ft. Project vertically to read gas velocity of 25 ft per sec. This is the required velocity of 0.46 lb per cu ft gas which will float a ¼-in. particle.

Step 4. To determine required compressor capacity to provide above determined amount of gas, enter Chart 3 at velocity of 25 ft per second, find intersection with annual area of the 6¼-in. hole and 3½-in. drill pipe of 22 sq in., project horizontally to intersection with gas density of 0.46 lb per cu ft and read free gas volume of 3,100,000 cu ft per day at standard conditions of 68 F and 14.7 psia.

If the example were desired for air drilling, the amount of air may be determined in the same manner and read on the same air scale in Chart 3.

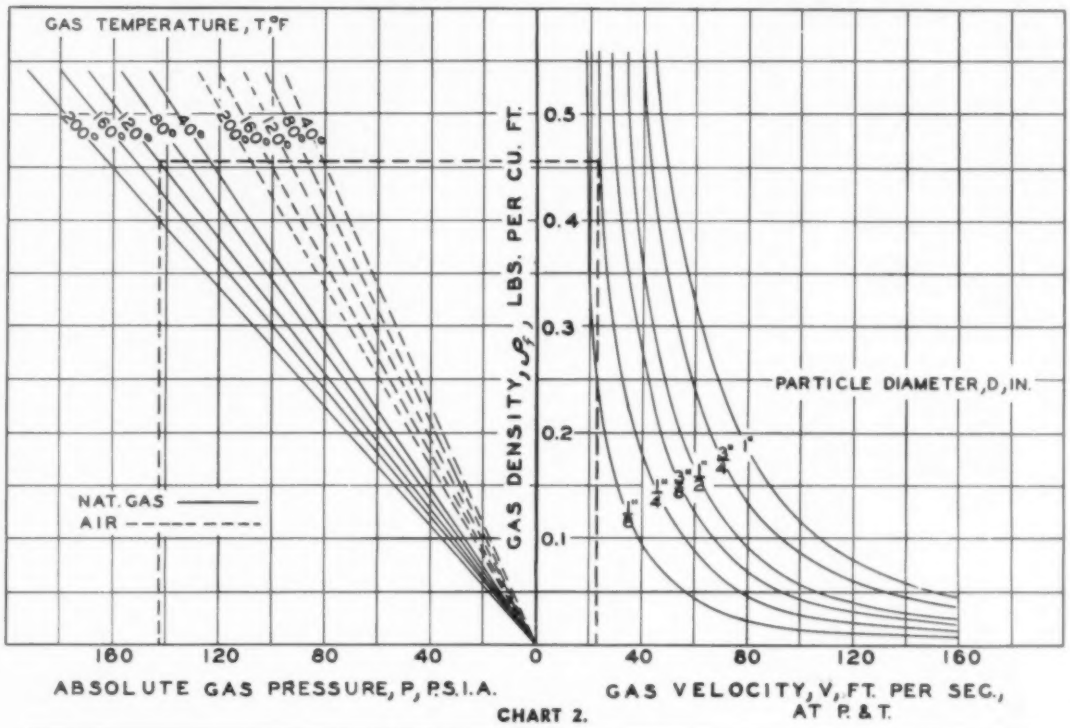

CHART 2.

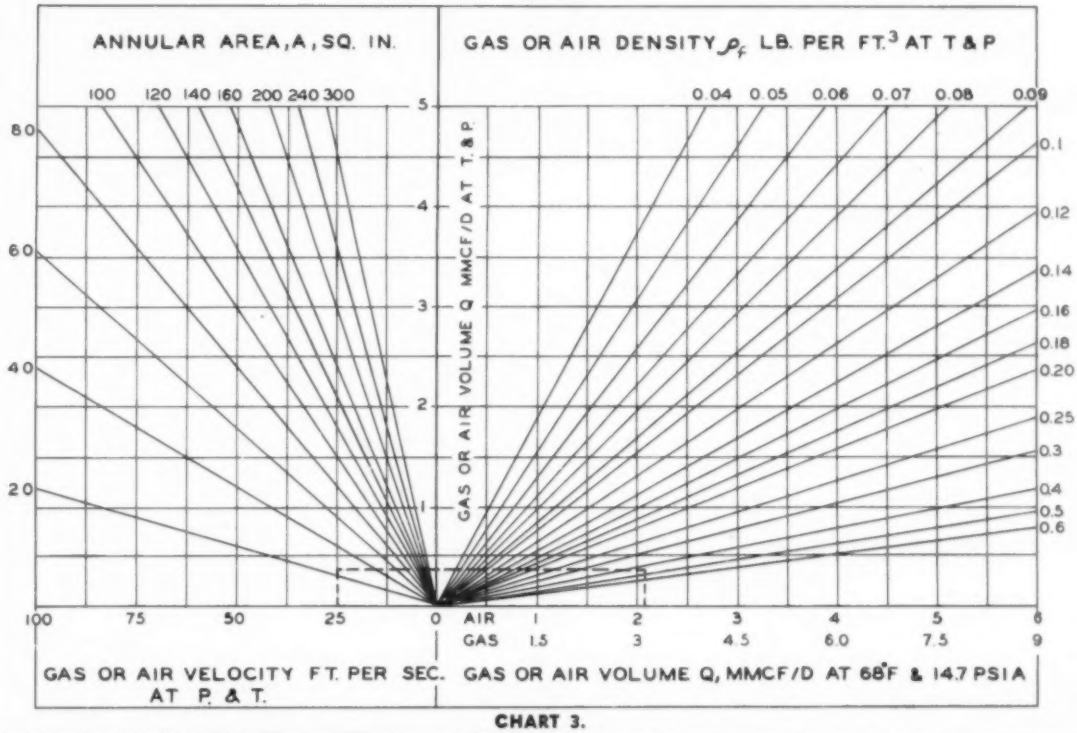

CHART 3.

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101

Buchanan Heads 1958 Officer Slate

George S. Buchanan, director of Husky Oil Company, Cody, Wyoming, will become the 42nd president of the American Association of Petroleum Geolgoists on March 13. Serving with Buchanan on the 1958-59 executive committee of the organization will be Graham B. Moody, consulting geologist, Berkeley, California, as past president; the present editor of the AAPG monthly Bulletin of Petroleum Geology, Sherman A. Wengerd, professor of geology, University of New Mexico, Albuquerque, and two other newly elected officers: Vice President Gordon I. Atwater, senior member of Atwater, Cowan & Associates, New Orleans, Louisiana, and Secretary-Treasurer Harold T. Morley, chief geologist, Pan American Petroleum Corporation, Tulsa, Oklahoma.

The new slate of AAPG officers will assume the responsibility of directing the 14,000-member organization at the close of the 43rd annual meeting of the association being held at the Biltmore Hotel, Los Angeles, California, March 10-13.

Retiring members of the present AAPG Executive Committee are Past-President Theo A. Link, president, Cree Oil of Canada, Ltd., Calgary, Alberta, and Toronto, Ontario; Vice President Byron W. Beebe, vice president and director of production, Keating Drilling Company, Oklahoma City, and Secretary-Treasurer William J. Hilseweck, partner, Blackwood & Nichols, Dallas, Texas.

President-elect Buchanan is a native of Colorado. After receiving the MS degree in geology from the University of Michigan in 1924, Buchanan was employed by the Pure Oil Company as a paleontologist, in Tulsa, Oklahoma. He later joined the Carter Oil Company as a paleontologist-geologist. From 1928 to 1933 he was director, and chief geologist for the Tulsa Oil Company. From 1934-39, Buchanan was president and director of Adams Oil & Gas Company in Houston. During the years of 1940-44 he was president and director of the Adams Oil & Gas Company in Houston. During the years of 1940-44 he was president and director of the Yegua Corporation in Houston, and vice president of the Sohio Petroleum Company of Houston from 1944 to 1953. Since 1953 he has been vice president and director of the Husky Oil Company of Cody, Wyoming.

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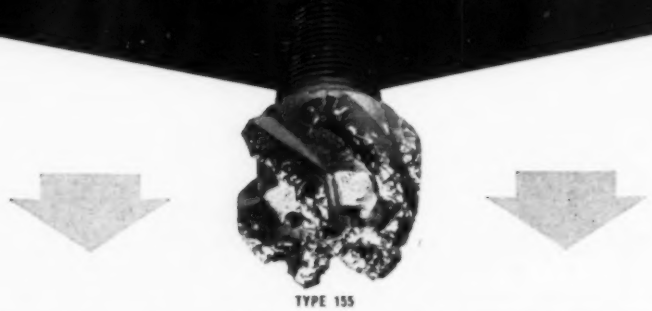

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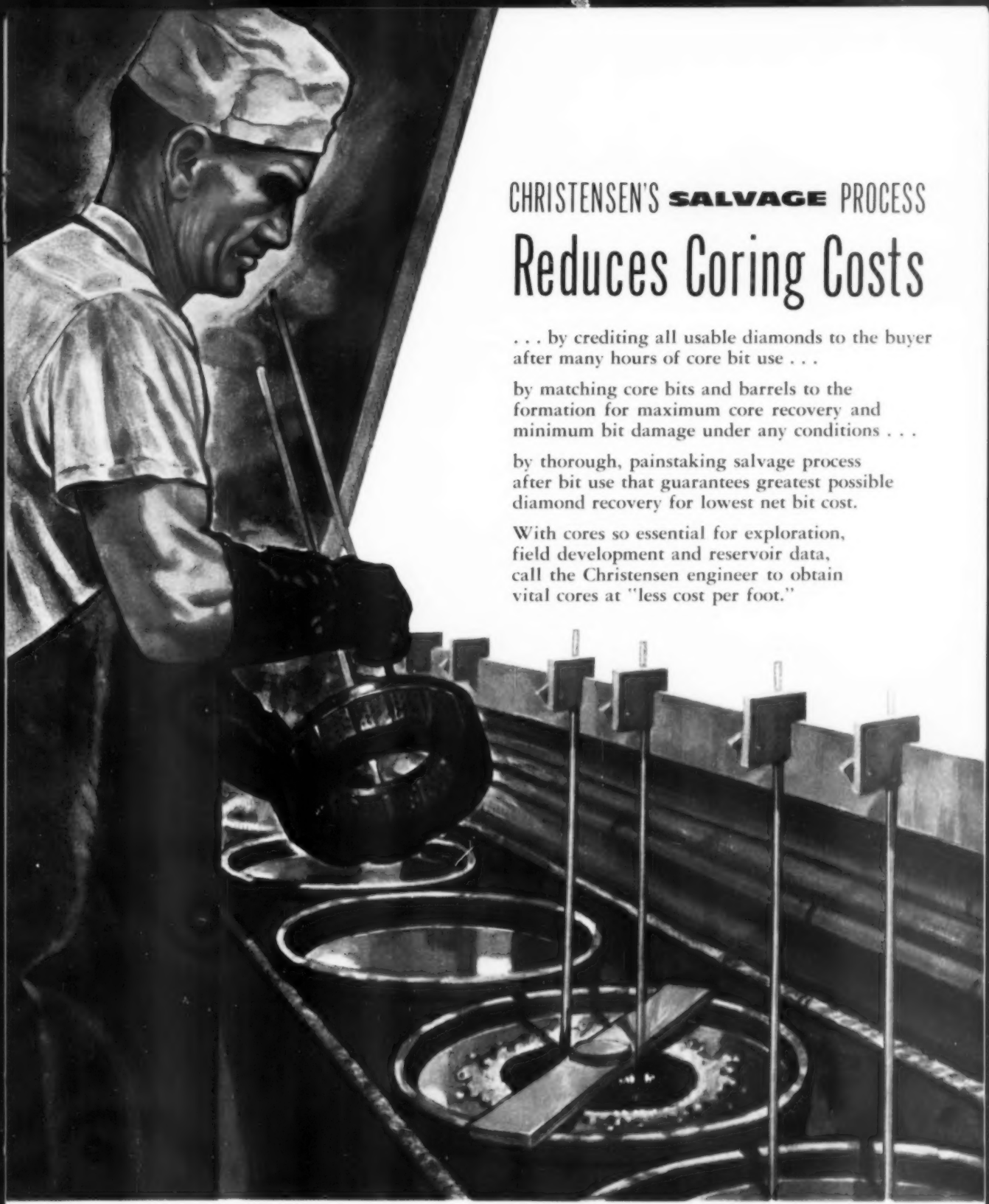

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* See the complete Martin Catalog and instructions in the 1957 Composite Catalog.

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Kantzer Named President, Society of Petroleum Engineers

Basil P. Kantzer, manager of operations of the Gulf Division of the Union Oil Company of California, was installed as 1958 president of the Society of Petroleum Engineers of AIME at the annual AIME Meeting, February 16-20, in New York.

Vice presidents for 1958 are B. L. Francis, assistant division manager for The Texas Company, New Orleans, and E. N. Van Duzee, production manager of Shell Oil Company's Midland, Texas, area.

Kantzer joined Union of California in 1934 as a roustabout after receiving a petroleum engineering degree from Stanford University. By 1942 he had progressed to division foreman and in 1943 was named chief production engineer. Kantzer assumed the position of manager of California field operations in 1948, and in 1950 was promoted to manager of natural gas and gasoline, both domestic and foreign. He assumed his present position in 1955.

Francis holds a petroleum engineering degree from Louisiana State University and joined The Texas Company shortly after graduating in 1941. In 1950 he became district petroleum engineer for the Houma district, and in 1952 was named assistant division petroleum engineer. He assumed his present position in 1955. Francis has held various offices in the Delta section of AIME, including chairman in 1955 and a director in 1956.

Van Duzee received a degree in mining engineering from the University of Minnesota in 1926 and immediately joined Roxana Petroleum Corporation, predecessor of Shell Oil Company. In 1939 he was made manager of the New Orleans area. After completing a years' assignment in Shell's New York office, he was named to his present position in 1947. Van Duzee has served as vice chairman of the Delta section and as a member of the Society executive committee from 1952 until 1955.

Board of Directors

Also installed were five new members of the Society of Petroleum Engineers Board of Directors who will begin serving staggered terms in 1958.

R. A. Morse (three-year term), associate director of research for Gulf Research & Development Company, Pittsburgh, was 1953 chairman of the Society publications committee and in 1957 served as chairman of the Society technology committee.

Harry D. Campbell (three-year term), president and general manager of Franco Western Oil Company, Bakersfield, California, in 1954 and 1955 was an AIME section delegate and was chairman of the San Joaquin Valley local section in 1954.

Roy A. Bobo (three-year term), director of the drilling engineering division of Phillips Petroleum Company's production department, is a past chairman of the Gulf Coast section of AIME and in 1956 was chairman of the Society technology committee.

Raymond E. Howard (two-year term), regional petroleum engineer of the West Texas-New Mexico region for The Atlantic Refining Company, was the first chairman of the Society section conference and has served as a member of the Society membership, nominating, and technology committees.

Raoul J. Bethancourt (one-year term), division staff petroleum engineer for the Sun Oil Company, Dallas, helped organize the Southwest Texas section of AIME and was section chairman in 1949 and section delegate in 1948 and 1949. He also served as 1956 chairman of the Society admissions committee and as 1957 chairman of the Dallas local section.

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EXPLORATION ACTIVITIES

PARAGUAY

Rimrock, IPC Plot Joint Venture

International Products Corporation and Rimrock Tidelands, Inc. will share in development of a 7,500,000-acre concession granted by the Paraguayan Government. A Rimrock rig is on the move from Louisiana to "put feet" to the proposed venture.

The concession consists of 3 tracts in the Chaco region of Paraguay, in the same general area where Pure Oil Company has announced plans to commence drilling operations immediately on its concession.

Two of the tracts totaling about 4,000,000 acres, lie along and parallel the Bolivian and Argentine borders. They are located close to 5 Bolivian and 3 Argentine oil and gas fields, which are productive in the Devonian formation. The third tract of about 3,500,000 acres adjoins the Pure Oil concession in northeastern Paraguay.

Rimrock Tidelands will be the operator and drilling contractor for the oil exploratory program. International Products' extensive facilities in Paraguay, including machine shops, foundries, surface and air transportation, will be used to support the exploratory operations. Immediate plans are being made to transport one of Rimrock Tideland's drilling rigs in the Louisiana Gulf Coast area to Paraguay for the earliest possible commencement of drilling operations.

VENEZUELA

Lake Test Flows 4040 Bbl

Closely watched Centro 3X, in Lake Maracaibo, has been completed flowing 4040 bbl per day. The exploratory well is a joint venture operated by Signal Oil and Gas of Venezuela, operator of a 28,000-acre concession in the lake for foreign subsidiaries of Signal, Hancock, Pure, and Ohio Standard.

The well flowed 41.3 deg gravity oil cutting 2/10 of one percent. Centro 3X was perforated in several more sections of the same zone in which a previous exploratory well, Centro 2X, was tested. One exploratory rig and one development rig are working on the Lake Maracaibo concession.

CANADA

Gas Discovery in Foothills

Shell Oil Company of Canada, Ltd., has reported a gas discovery in the Devonian formation at its Panther River No. 1, in the foothills area of Alberta. Well is about 60 miles northwest of Calgary and 30 miles northeast of Banff. Early tests of the Fairholme section of the Devonian between 9009 and 9116 ft brought gas to the surface immediately, which built up to a maximum rate of 7,200,000 cu ft daily before shut in. Further tests are being made. Top of the Fairholme zone was called at 8988 ft. This is the first foothills discovery in this zone, thus opening a new area for gas exploration.

LIBYA

Rig Nearing Desert Site; May Test to 15,000 Ft

Some 7500 tons of drilling equipment and supplies are making the long journey from Tripoli into the desert where Oasis Oil Company of Libya's first exploratory well will be drilled.

Oasis Oil is a wholly owned subsidiary of the Ohio Oil Company and is the operating company for Libyan concessions totaling nearly 62,000,000 acres. Ohio Oil, Continental Oil, and Amerada Petroleum hold undivided one-third interest in these concessions.

The equipment, which was shipped from the U. S., was loaded at Tripoli on trucks and moved east 325 miles on a paved road along the seacoast. The caravan then will turn south from the Gulf of Sirte and roll over the desert for 75 miles to the test site.

International Drilling Company, N. V., which has contract for the well, expects to be rigged up and ready to spud the exploratory test before the end of April. The wildcat will test a long north-south trending anticline which was mapped by Oasis Oil geologists. A seismograph survey followed which confirmed the surface work.

The well may go as deep as 15,000 ft probing for oil. Drill pipe and sufficient casing and tubing to carry the well to that depth and tube it in the event the wildcat well finds oil, already have been shipped from the Port of Baltimore.

Casing Set at Third Atshan Try

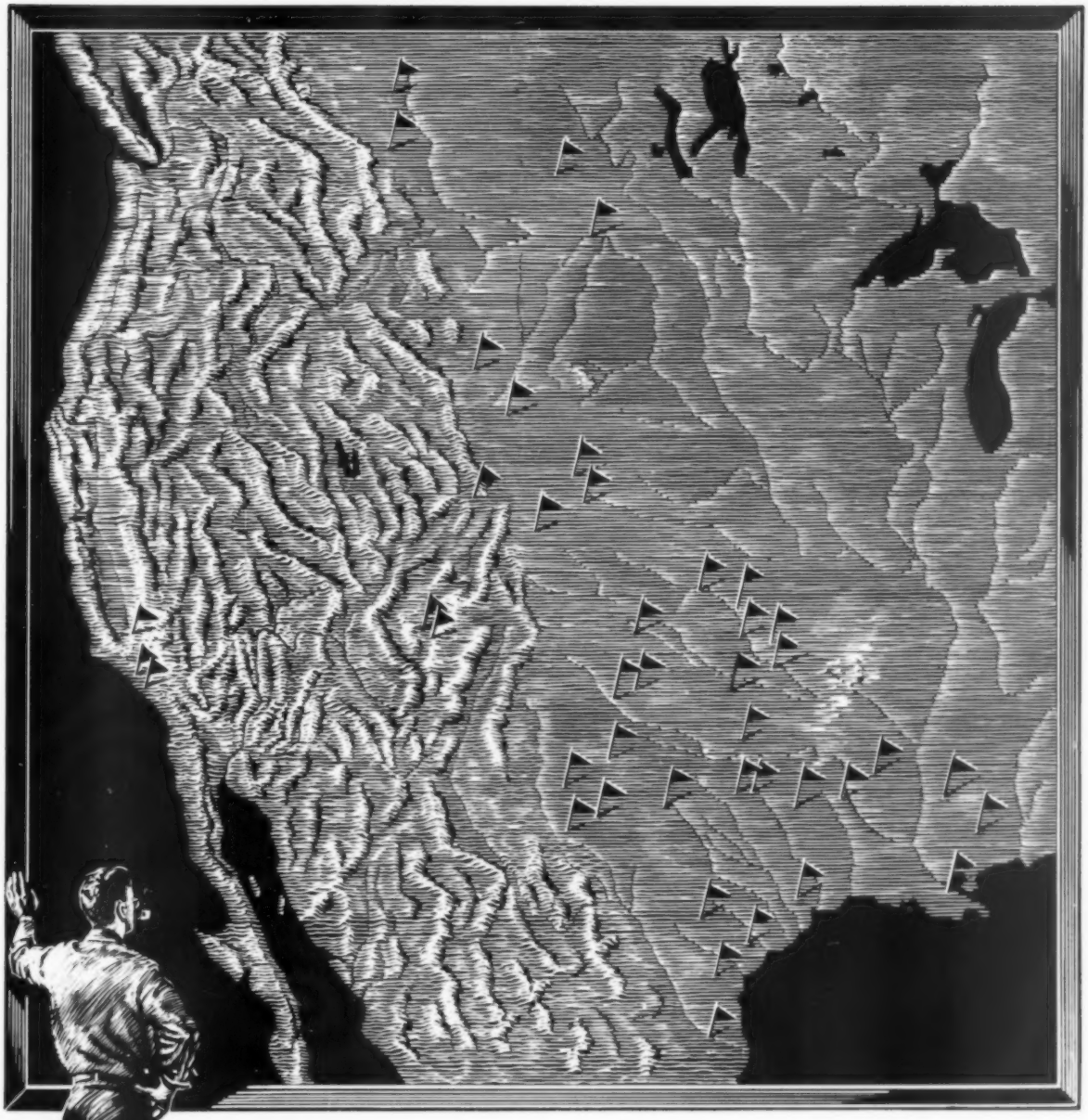
Esso Standard (Libya), Inc., Jersey Standard subsidiary, is conducting production tests in an attempt to establish commercial oil producion in Libya. Casing has been set at about 2900 ft at the Atshan No. 2, the third Esso well drilled. Two previously drilled holes were dry. The new prospect is in the Fezzan area about 400 miles south of Tripoli.

NEW MEXICO

Deep Gas Found in Eddy County

Pan American Petroleum Corporation and Buffalo Oil Company have jointly completed the Greenwood Unit No. 2, as a gas discovery in Eddy County. The well produced a potential of 6,640,000 cu ft of gas and 840 bbl of 60 deg condensate a day through a 44/64-in. choke from perforated zones at 10,912-48 ft and 11,425-38 ft.

The wildcat find is approximately half a mile from the two companies' Greenwood Unit No. 1 which produced from a different depth.



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Exploration

COLORADO

SE Baca Test Gets Gas, Oil

Shell Oil Company has an apparent gas and oil discovery at its No. 1 Federal Land Bank in southeastern Baca County. Location is in C SE NE of 31-34s-44w, west of Lamport townsite and about four miles north of the Cimarron County, Oklahoma, line. Pipe was set in the Cherokee with well drilled to TD of 5305 ft. Tests conducted in the drilling phase in this zone yielded 1,800,000 cu ft of gas a day at 4240-70 ft. The Des Moines, drillstem tested at 4096-215 ft, yielded gas at the rate of 1,400,000 cu ft of gas per day; 480 ft of oil and 270 ft of mud and water were recovered. Additional tests of both zones are to be made.

Shell is rigging up at its No. 1 Moore, about nine miles northeast of the apparent discovery, and will drill to 5400 ft or to the Mississippian.

WYOMING

Confirmation Try at Meyer Gulch

Hamilton Oil & Gas Corporation is drilling under surface on an attempt at confirmation to the lone producer in the Meyer Gulch field. Located in the Big Horn Basin in Washakie County, Meyer Gulch was discovered by Superior Oil Company in 1955.

Farmout was given to Hamilton by Phillips Petroleum for the new test, scheduled to the Phosphoria-Tensleep at around 9000 ft, for this northwest offset to the discovery well. Meyer Gulch lies south and slightly east of the Cottonwood Creek field, one of the major producing areas in the Big Horn Basin.

TEXAS

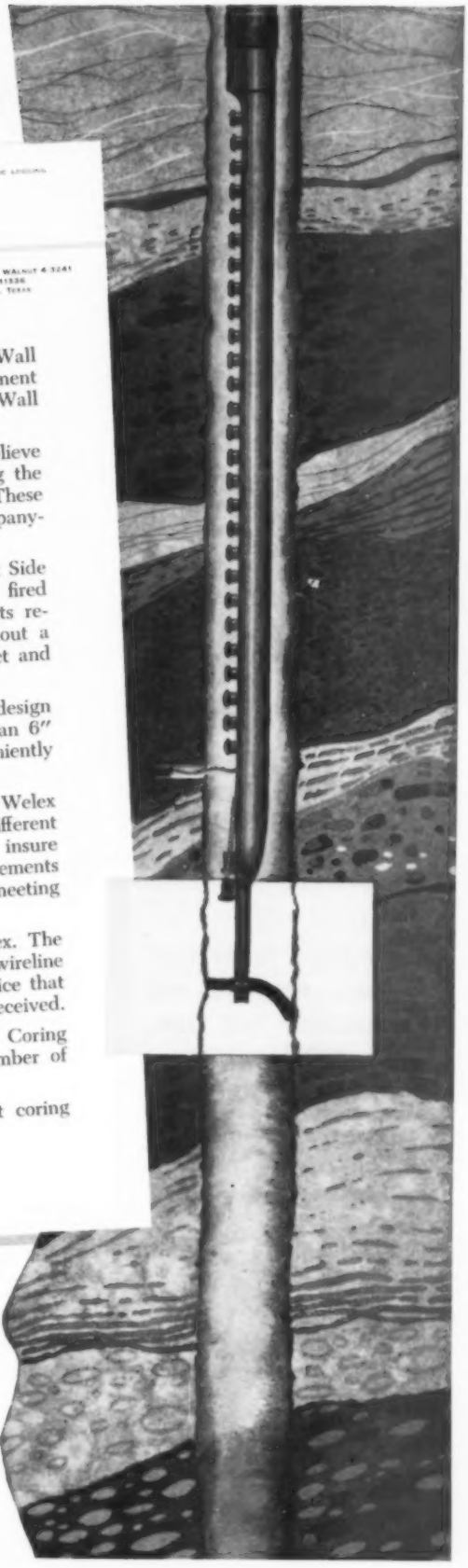
New Tests on Barber's Hill

An exploration deal to test some 8000 acres on the outer flanks of Barber's Hill dome in Chambers County has been completed between Michael T. Halbouty and Kirby Petroleum Company, fee owner of the property.

The acreage, located on all flanks of the prolific dome, has been divided into exploration blocks. A 13,500-ft Yegua test, Halbouty's No. 1 Wilborn, is drilling on one block on the north flank, a mile and a half north of nearest Yegua production. Halbouty is also conducting geophysical work on some 4000 acres in the area, at present.

The arrangement calls for Halbouty to carry on a continuous exploration program of drilling or geological or geophysical work with the hope of establishing new and deeper production on the outer flanks of the dome which has given up more than 100,000,000 bbl of oil from Miocene, Frio, Vicksburg and Yegua sands.

HERE'S PROOF...



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3. Both the powder loads and the core barrels of the Welex Side Wall Coring gun may be varied to meet the different conditions which exist even in the same hole to insure larger cores every time by meeting these requirements as indicated on the Welex Electric Log, not by meeting general field conditions.
4. Top flight service is yours every time with Welex. The confidence of the entire oil industry in Welex wireline tools has been earned by years of unexcelled service that men in your position have demanded . . . and received.

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Exploration

CUBA

White Eagle Starts First Test

White Eagle International Oil Company has started the first wildcat well to test its concession acreage in Cuba and is now drilling below 4400 ft. Well is being drilled by Cuban Stanolind Oil Company under a farmout agreement between White Eagle International and Cuban Stanolind which affects about 1,000,000 acres in the southeastern portion of Cuba. The wildcat well is the Lavanderas No. 1 situated off the west coast of southern Cuba about 10 miles west of the town of Campechuela. The well is being drilled from a location in about six feet of water on a shallow coral reef, and is expected to be drilled to an approximate depth of 9000 ft, depending upon the sediments encountered in the course of drilling.

SAUDI ARABIA

More Oil at Manifa

Drillstem tests at Manifa No. 1, the discovery well in the Arabian American Oil Company's second offshore field in the Persian Gulf, indicates a possibility of oil in commercial quantities between the Zubair and Arab zones. Indicated new producing zones are between 7600 and 8300 ft under the Gulf bed.

Drillers have been running tests at the offshore well 120 miles northwest of Dhahran, Aramco's headquarters, since oil was discovered there in mid-December. Zones now being tested at Manifa have been unproductive elsewhere in Saudi Arabia.

Drilling has continued in Manifa No. 1 to a total depth of 9637 ft. The A, B, and C members of the Arab zone have been found productive. The D member of the Arab zone, which is highly productive member in Aramco's inland Abqaiq and Ghawar fields, has been found unproductive at Manifa.

Additional wells and further tests will be required in Manifa to evaluate fully the significance of the recent discoveries there, Aramco reports.

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ALASKA

24 Lease Hats in the Ring

About 18,000,000 acres in Alaska are now under lease by 24 oil and gas companies, Anchorage Chamber of Commerce reports.

Two wildcats are now drilling. Humble Oil & Refining is drilling on the Alaska peninsula, while Colorado Oil & Gas Corporation is drilling at its test in the Yakutat area. A joint venture of Standard of California and Richfield is in the planning stages for activity on the Kenai peninsula and Shell and Humble are shaping a combined exploratory program on the Alaska peninsula. Both will involve about $30,000,000 each.

Richfield is drilling an offset well to its No. 1 Swanson River, a 900-bbl per day discovery on the Kenai peninsula.

In addition to these companies are several others. These include Gulf, Texaco, Husky, Skelly, Ohio Oil, Phillips, General Petroleum, Ocdanic Oil, Superior, Texola Oil, Franco Western, Honolulu Oil, Reserve Oil & Gas, Union of California, Three States Natural Gas, Great Basin Petroleum, the Benedum Interests, and Atlantic.

OKLAHOMA

Lion Gets New Gas in Harper

Lion Oil Company Division of Monsanto Chemical Company has successfully completed the Doby No. 1 in Harper County, as a discovery gas well with an open flow potential of 54,000,000 cu ft per day. The well is producing through perforations in the Morrow sand.

The Doby is located in Section 1, township 27n, range 24w. The company has full interest lease on the 640-acre tract on which the well is located, and has full interest and partnership leases on some 3000 additional acres in the vicinity of the discovery well.

BOLIVIA

Group Gets 2,250,000 Acres

The Bolivian Government has granted concessions totaling about 2¼ million acres to a group composed of Blackwell Oil and Gas Company, Western Hemisphere Petroleum Corporation, and White Eagle International Oil Company. The concessions granted lie in Zones I and II as designated by the Bolivian Government in the central region of the country on the eastern flank of the Andes Mountains.

The new holdings border on concessions previously granted to subsidiaries of Shell, Gulf, and other oil operators. White Eagle International is the operator for the three-company venture, and plans for development of the concessions are now in progress.

What's doing in DRILLING

Dixilyn Drilling Christens Mobile Offshore Platform

More than 700 people were on hand on January 14 to witness the christening of the Gulf Coast's latest "portable" offshore platform. Ceremonies in New Orleans commissioned the "Julie Ann" for Dixilyn Drilling Corporation.

The "Julie Ann" is the fourth of the large-type platforms built by R. G. Le Tourneau, Inc. This platform is designed and equipped to operate in water over 100 ft deep to drilling depths in excess of 25,000 ft. Spud tanks on the bottom of each 175-ft leg are over 35 ft in diameter, providing a large bearing surface to rest solidly on the ocean bottom. The platform can raise or lower itself at a rate of one foot per minute with simple electric switches operating all legs simultaneously or, for leveling purposes, each leg independently.

The rig is a complete unit including, among other equipment, ample pipe racks for casing and drill pipe, a logging unit, a cementing unit, de-sander and de-gasser, a mud laboratory, and a salt water evaporator. The million-pound, two-well derrick is mounted in such a manner as to permit the drilling of six wells from the same platform location.

Operational headquarters for "Julie Ann" will be New Orleans, Louisiana.

Giant Rig Moves to Venezuela

A new super-powered oil well drilling rig — the latest word in well drilling equipment — has been put into operation in Maracaibo, Venezuela. Assembled by International Brown Drilling Company, the big-muscled unit has a power plant consisting of three 800-hp engines. The unit can handle drilling operations to 15,000 ft.

Continued on page B-145

Drilling Activity Registers Slight Increase

An encouraging reversal of the downward trend in drilling activity was recorded the first week in February. Rotary rig activity began its downward spiral on December 16, 1957, after reaching the highest point of the year: 2842 active rigs in the United States and Western Canada. By January 27, 1958, this total had dipped to 2083 active rigs, reaching an eight-year low. But the upward swing saw 2174 rigs busy on February 3, 1958.

The drilling business was in ill health during 1957 and one drilling analyst estimated that more than 100 contract drilling companies dropped out of business during the year. The present slump in activity is generally expected, but the fall has been more severe in early 1958 than usual.

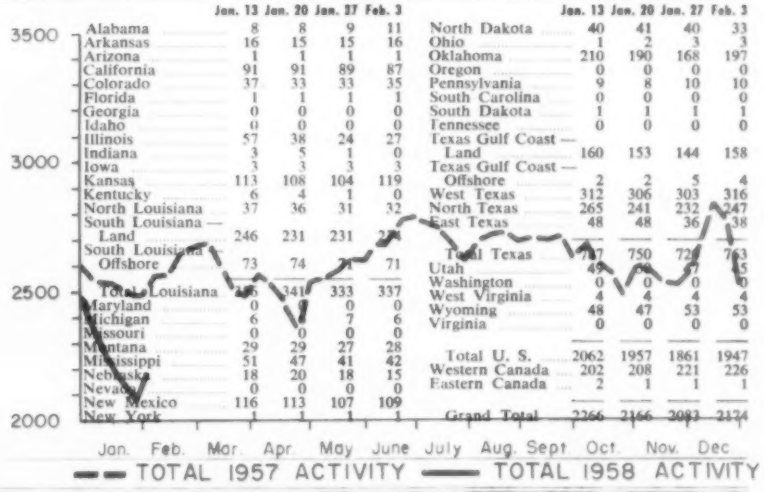
High levels of crude oil imports have received most of the blame for the drillers' woes, in spite of reduced imports resulting from the government's voluntary import quota program. One drilling industry representative, Jack Bates, Jr., of Reading & Bates, Inc., has stated: "We're at the start of a new year and the oil companies aren't yet in the swing of their budgets, so we might have a little pick up there. But the basic evil still is too much oil above the ground. Until we get that worked out, we see nothing to pick up drilling to former levels of around 2700 rigs."

One large southwestern oil company reports it has changed its policy of budgeting money for a certain number of oil wells to planning just from well to well. "Right now we're just playing it by ear," a company official says. "After the first quarter, we might set up a budget, depending on conditions."

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company

	Jan. 13	Jan. 20	Jan. 27	Feb. 3
Alabama	8	8	9	11
Arkansas	16	15	15	16
Arizona	1	1	1	1
California	91	91	89	87
Colorado	37	33	33	35
Florida	1	1	1	1
Georgia	0	0	0	0
Idaho	0	0	0	0
Illinois	57	38	24	27
Indiana	3	5	1	0
Iowa	3	3	3	3
Kansas	113	108	104	119
Kentucky	6	4	1	0
North Louisiana	37	36	31	32
South Louisiana — Land	246	231	231	2[illegible]
South Louisiana — Offshore	73	74	[illegible]	71
Total Louisiana	[illegible]	341	333	337
Maryland	0	[illegible]	0	0
Michigan	6	[illegible]	7	6
Missouri	0	0	0	0
Montana	29	29	27	28
Mississippi	51	47	41	42
Nebraska	18	20	18	15
Nevada	0	0	0	0
New Mexico	116	113	107	109
New York	1	1	1	1
North Dakota	40	41	40	33
Ohio	1	2	3	3
Oklahoma	210	190	168	197
Oregon	0	0	0	0
Pennsylvania	9	8	10	10
South Carolina	0	0	0	0
South Dakota	1	1	1	1
Tennessee	0	0	0	0
Texas Gulf Coast — Land	160	153	144	158
Texas Gulf Coast — Offshore	2	2	5	4
West Texas	312	306	303	316
North Texas	265	241	232	247
East Texas	48	48	36	38
Total Texas	[illegible]	750	72[illegible]	763
Utah	49	[illegible]	[illegible]	5
Washington	0	0	0	0
West Virginia	4	4	4	4
Wyoming	48	47	53	53
Virginia	0	0	0	0
Total U. S.	2062	1957	1861	1947
Western Canada	202	208	221	226
Eastern Canada	2	1	1	1
Grand Total	2266	2166	2083	2174



Western engineering of well completion and remedial practices utilizes the skills and efforts of engineers in **all** phases of well servicing.

For example, to insure greatest possible fracturing productivity, the Western Field Services Engineers will tailor the frac jobs to the requirements of your wells.

Working with all available well and offset information and experience, these engineers plan the fracturing treatments to adapt Western's many specialized products and services to your well conditions with a detailed treatment procedure.

Then field engineering takes over, seeing that the recommended treatment is carried out—with specialized equipment—to gain the most economical and profitable results.

Your well servicing program can benefit from the engineering know-how of the Western Services Engineer. Get the many advantages of Western engineering in all completion and remedial work.

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Integrated wire line and pumping services for the Southwest: logging, perforating, fracturing, acidizing.

Are you playing blind man's bluff?

Know from the very start where your bits are going!

Eastman specialized experience in sub-surface surveys and Directional Drilling takes the guesswork out of drilling operations. Methods, techniques and specialized instruments developed and perfected by Eastman make it possible to direct the course of a drilled hole in any desired direction and toward any predetermined objective.

In applying this specialized science of Directional Drilling, Eastman Engineers not only help oil operators avoid losses of time and money but aid in solving problems of sidetracking, straightening and deflecting the course to reach otherwise inaccessible locations. Eastman is at your service day or night anywhere in the world. *Call today!*

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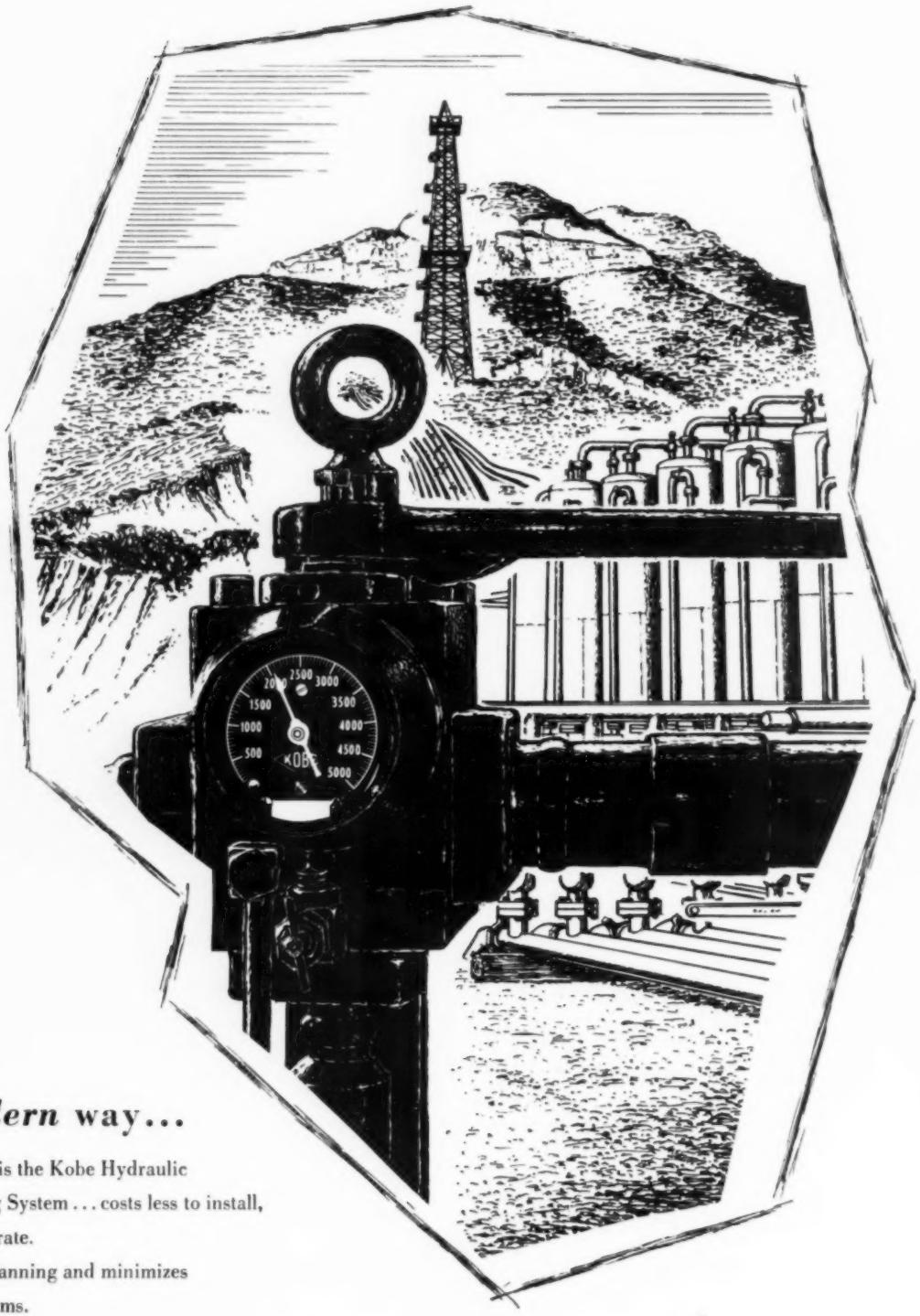

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to pump oil wells is the Kobe Hydraulic Oil Well Pumping System . . . costs less to install, maintain and operate.

Simplifies lease planning and minimizes production problems.

Easily transferred.

KOBE HYDRAULIC OIL WELL PUMPING SYSTEM

Free Pump

KOBE

HUNTINGTON PARK, CALIFORNIA

Continued from page B-141

The new drilling unit is the fourth sent to Venezuela by the firm's foreign division. The Venezuelan drilling contract is the 16th foreign contract which the Brown firm has undertaken. Other foreign operations have occurred in Saudi Arabia, Bahrein Island, France, Australia, Turkey, New Zealand, and Trinidad.

California Offshore Contract Awarded

Western Offshore Drilling & Explorations Company, Long Beach, California, has been awarded the contract to drill offshore wells for Standard Oil Company of California and Humble Oil & Refining Company on the joint lease held by the latter two companies covering 5500 acres of state-owned submerged lands off the Summerland area of Santa Barbara County.

California Standard's platform will measure 110 ft square and will have its deck 50 ft above the surface of the ocean, topped by a 140-ft derrick during drilling operations. It will be capable of drilling two wells simultaneously — an innovation in offshore operations — and up to a total of 25 wells from a single location.

Contract Completed for Wyoming Deep Test

Cataract Mining Corporation has announced the completion of an exploratory drilling agreement with The California Company whereby The California Company has agreed to drill a deep test on a large block of leases totaling approximately 25,000 acres which are located adjacent to proved gas production in the Green River Basin of Sweetwater County, Wyoming. The California Company has agreed to pay all expenses in connection with the drilling and completion of this project.

Cataract Mining holds an additional large block of acreage adjacent to these leases on which negotiations for additional drilling agreements are currently going on.

Drilling Company Establishes Scholarships

Garvey Drilling Company, Great Bend, Kansas, used a unique method of expressing their appreciation to their customers at Christmas time. The company established six $500 scholarships in petroleum engineering in the name of their customers in lieu of tangible gifts as had been given in the past.

The six schools given the scholarships were Wichita University, Kansas University, Kansas State College, Oklahoma University, Nebraska University and Colorado School of Mines.

Israeli Engineer Claims New Drilling Method

An Israeli petroleum engineer, Leon Nissimov, is offering a new physiochemical method for oil well drilling. The addition of certain chemical products to the mud reduces the hardness of the rock to an extent that the bit's penetrating speed is increased substantially, according to Nissimov. Efficiency of the method also is assured by automatic measurement. Construction of an apparatus measuring simultaneous action of factors affecting rate of penetration of rotating bits is proposed.

Louisiana Invites Bids on State Lands

The Louisiana Mineral Board has advertised for lease March 20, 1958, state lands totaling 7593 acres in 16 tracts ranging from 15 acres to 2691 acres. The board will also take bids for geophysical exploration of the Russell Sage wild life refuge on Marsh Island, some 60,000 acres, about five miles out in the Gulf of Mexico off Iberia Parish.

The largest state tract offered for mineral lease is one of 2691 acres in Terrebonne Parish.

For the "MR. CAP" They Chose a

Thompson . . . Perfect for Offshore Work!

On offshore rigs the reclamation of mud is vitally important and the separation of shale and abrasives from drilling muds means a more effective, time and money saving drilling job. Barnwell Offshore, Inc. chose Thompson for their new offshore rig, the MR. CAP, because it was field proven, will give them clean mud and make tools last longer, with a minimum of re-tooling and restoration of mud solution.

A Thompson Separator is your surest bet onshore . . . offshore . . . for shallow, medium and deep wells. The dependable Sample Machine works simultaneously with the separator, giving a foot-by-foot mud analysis with specimens. Write for Folder.

THOMPSON TOOL CO.
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THE OASIS—

Nomads Elect, Install New Officers

Houston

More than 700 saw Houston Chapter's installation of 1958 officers, a highlight of the group's 18th annual inaugural dinner-dance January 18. New officers are: (front row) W. O. Hedrick, Glaze-Hedrick Mfg. Co., senior regent; B. W. Pickard, Tuboscope, vice president; Ed Louden, president, Baroid; Tracey Word, Jr., Thornhill-Craver, junior regent; Harry Estes, Oil Well Survey Instruments, executive secretary; (back row) W. H. Becker, Atlas Pipe, sgt. at arms; F. S. Mims, Mission Manufacturing, asst. treasurer; John W. Gates, Well Equipment Manufacturing, secretary; A. Lon Smith, Petroleum Instruments Company, asst. secretary, and W. M. Boren, Rolo Manufacturing, deputy sgt. at arms.

Dallas-Fort Worth

Dallas-Fort Worth Chapter Nomads 1958 Officers and Regents are: Abbott Sparks, The Petroleum Engineer, senior regent; L. D. Webster, Lone Star Steel, deputy sergeant at arms; Joe B. Woods, The Petroleum Engineer, assistant secretary; Henry G. Streidl, Varel Manufacturing, secretary; G. H. Lewis, Continental-Emsco, junior regent and retiring president; Rollo E. Davidson, Drilling magazine, president; R. E. Elmore, Mid-Continent Supply, executive vice president; R. J. Evans, Byron Jackson Tools, vice president (Fort Worth); J. A. Kelly, Reed Roller Bit, sergeant at arms; K. Marshall Fagin, Southwestern Life Insurance, treasurer; King D. Boyd, Oilwell Supply, deputy sergeant at arms. Officers not pictured are Gordon G. Wilbur, Ideco, Inc., vice president (Dallas) and Webb M. Sowden, Hewitt Rubber, assistant treasurer.

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Los Angeles

Outgoing and incoming officers of the Los Angeles Chapter of Nomads at the annual business meeting, January 9, left to right (front row) are: 1958 President Earl M. Daniels of Hydril Company; 1958 Junior Regent and retiring President Bob Gaylord of Wagner-Morehouse; 1957 Vice President Bill Brooks of Byron Jackson Tools; (back row) Senior Regent Harry Hester of McCullough Tool; 1957 Regent Joe Schlarb of Continental-Emsco; 1957 Secretary Tom Martin of R. J. Eiche & Associates; 1958 Treasurer C. F. Van Loozen of Macco Corporation; incoming Asst. Secretary Shorty Bowen of Martin-Decker; 1958 Deputy Sgt. at Arms Andy Anderson of Pacific Perforating; incoming Sgt. at Arms Tom Ashe of Globe Oil Tools; new Asst. Treasurer Taylor Bannerman of Totco. Not shown are 1957 Treasurer Ben Hilliard of Web Wilson; last year's Asst. Treasurer Ben Reinhold of Abegg & Reinhold; 1958 Treasurer Knight Templeton of S. R. Bowen, and incoming Vice President Earle Atkins, Devex Engineering.

New York

New York Chapter of Nomads new officers, elected January 13, are: (seated) Senior Regent Herb E. Maland, R. J. Eiche & Associates; President E. E. Andreason, Andreason-Lundberg Corporation; Vice President Don E. Kircher of Gardner-Denver; Junior Regent Maurice F. Delano Jr., R. S. Stokvis & Sons; (standing) Executive Secretary E. W. Hoeppner, Hughes Tool; Asst. Secretary John E. George, Mid-Continent Supply; Sgt. at Arms Harold E. Lowrey, Continental-Emsco; Treasurer W. E. Volkman, Cardwell Manufacturing. Officers not shown include Asst. Treasurer R. L. LeBus Jr., Baash-Ross Tool; Secretary Hollis W. Haltom of Beckley, Haltom & Hickman; Asst. Sgt. at Arms D. T. O'Connor, and Asst. Sgt. at Arms J. W. Chanda of A. O. Smith.

better drilling... better logging... better completions with **Seeco-Mul** *emulsifier*

Seeco-Mul is a dry, flaked compound of abietic, linoleic, and oleic acids, wood tannins, and lignins. It effectively disperses the oil content of emulsion mud systems and also has appreciable lubricating qualities which augment the desired lubricating effect of the oil. In almost all areas, Seeco-Mul emulsion muds increase drilling rates, make better hole conditions, drill into pay formations better, afford better coring, and protect the pay zone from water more effectively. Seeco-Mul readily emulsifies Diesel or crude oils in sodium or limed muds, it is temperature-stable, it has a low water loss at high temperatures, and any qualified mud engineer can use it without special instructions or extra equipment.

Seeco-Mul emulsion muds minimize hole enlargement, reduce water invasion of pay sands, allow better completions in zones with low pressures and low permeabilities, and allow wells to come in on production better, easier, and cleaner. The same logs as run in fresh water muds are entirely suitable in emulsion muds. Seeco-Mul muds often allow better logs to be obtained because the emulsion does not block the formation as in the case of water systems. Seeco-Mul increases the wetting action of the mud on the drill bit and the collars, which results in less drag, less torque, less balling of the bit on bottom, and fewer round trips.

Seeco-Mul has a number of other operating advantages which your local mud dealer will be glad to tell you about — or write to us. We'll be glad to send you illustrated literature and a lab sample without obligation. Crossett Chemical Company Division of The Crossett Company, P. O. Box 271, Crossett, Arkansas.

faster penetration... less balling on bottom less drill stem torque with **Seeco-Mul**

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For Dependable, Accurate Oil Well Metering...

CV VOL-U-METER*

VOL-U-METERS®
are ECONOMY in action

Designed for simplicity, constructed for dependability, the VOL-U-METER provides continuous, accurate oil well liquid volume metering performance at the lowest operating cost. *Maintenance cost averages less than $5.00 per unit per year!*

Additional savings mount up in the use of the VOL-U-METER. For example, on an Oklahoma Lease one CV VOL-U-METER was used on a dual completion well and tied into a common tank eliminating the need for dual tankage on the dual well. The second welded tank, which would have been required, would have cost approximately $1,750.00, about *three times the actual cost of the VOL-U-METER.*

VOL-U-METERS are available in three types of vessels, the CV, FV and FVC (Type FV with cone-shaped bottom).

TYPE CV is barrel-shaped and utilizes one liquid level control pilot system.

Type FV features two liquid level control pilot systems with one in each of the reduced necks.

TYPE FVC features a cone-shaped metering chamber which is lined with plastic. It has a liquid level control pilot system in the upper reduced neck and one in the lower neck, as does the FV. The FVC is designed for use where foreign matter in well fluid will probably settle in the vessel reducing its metering accuracy.

The three types of VOL-U-METERS are available in dump volumes from ¼ barrel to 10 barrels, with capacities of 300 to 4,000 BPD, and working pressures from 125 psi to 1200 psi for the CV and to 2400 psi for the FV and FVC.

They can be equipped with either pneumatic or electric controls. Write for the latest literature on the accurate oil and water VOL-U-METERS.

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Sales and service representatives in all major oil fields.

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The Oasis

Tulsa

Guy Williams, right, turns over his post as president of the Tulsa Chapter Nomads and takes the post of senior regent. Presentation was made at the chapter's annual inaugural ball January 17. Don Collins, outgoing senior regent, presents Williams with his past-president's key while Herb Cooley, master of ceremonies, looks on. John Pearce is the 1958 president.

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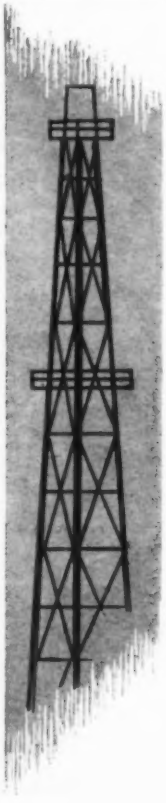

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No matter what your particular requirements for down-hole tools—for the most complete line of Stabilizers, Reamers, Scrapers, Hole Enlargers or Underreamers—Grant is ready with the size and type you need.

Grant maintains the largest and most complete tool stocks throughout active oil territory, available day or night. That's why it's easy for you to have the tools you want—when you want them. *Specify Grant!*

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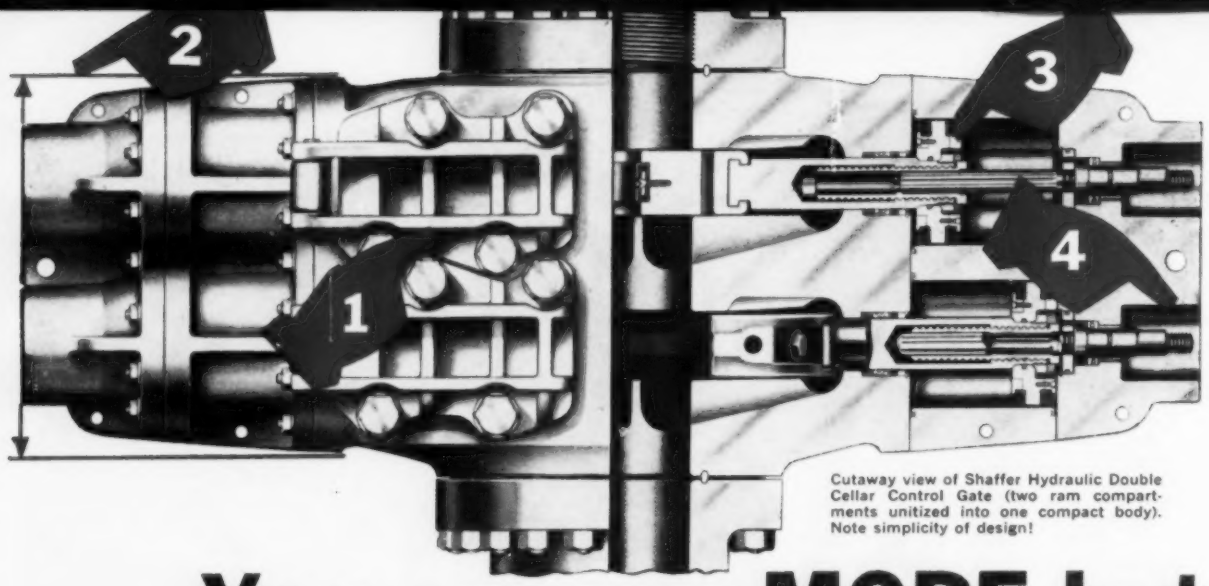


Cutaway view of Shaffer Hydraulic Double Cellar Control Gate (two ram compartments unitized into one compact body). Note simplicity of design!

You can pay MORE but you can't buy BETTER than SHAFFER Cellar Control Gates

Before you buy your next cellar control gate equipment, check the field. Note the unique years-ahead *features built into Shaffer Hydraulic Gates. Compare—and you'll find you can pay* more *for cellar control gates, but you can't buy better than Shaffer!*

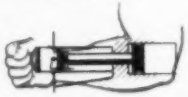
ADVANTAGE #1

Simply open convenient side doors to change rams—and closing the doors automatically aligns the new rams for proper operation. No extra room is needed above the gate—nor is added space required at the ends—to change rams. Moreover, complete ram changes can be made whether the pipe is in or out of the hole!

ADVANTAGE #2

Shaffer Gates are not only compact in all three dimensions—length, width and height—but there's no need to expand the gates endwise to change rams, nor need extra space be allowed above the gates for lifting out the rams. Even sizes as large as 13⅜" (12" Series 900) are only 18½" high in Single Gates—only 30" high in Double Gates!

ADVANTAGE #3



In Shaffer Gates there are no complicated yokes, no secondary connections between pistons and rams. For maximum safety and simplicity, each ram is operated by a single direct-connected piston!

ADVANTAGE #4

Whether you prefer the extra compactness of a non-rising locking shaft, or the quick indication of ram position afforded by a rising shaft, you choose the design you prefer when you select Shaffer Gates!

In addition, Shaffer Gates have *Self-Draining Compartment Bottoms* (no detrimental sand or mud accumulates to interfere with free ram travel)... *Completely Enclosed Design* (no exposed moving parts to become damaged or corroded)... *Built-In Flow Connections*, and many other unsurpassed features that add up to greater safety, greater dependability, greater convenience. Get the full story from your nearest Shaffer representative—or write direct for further details!

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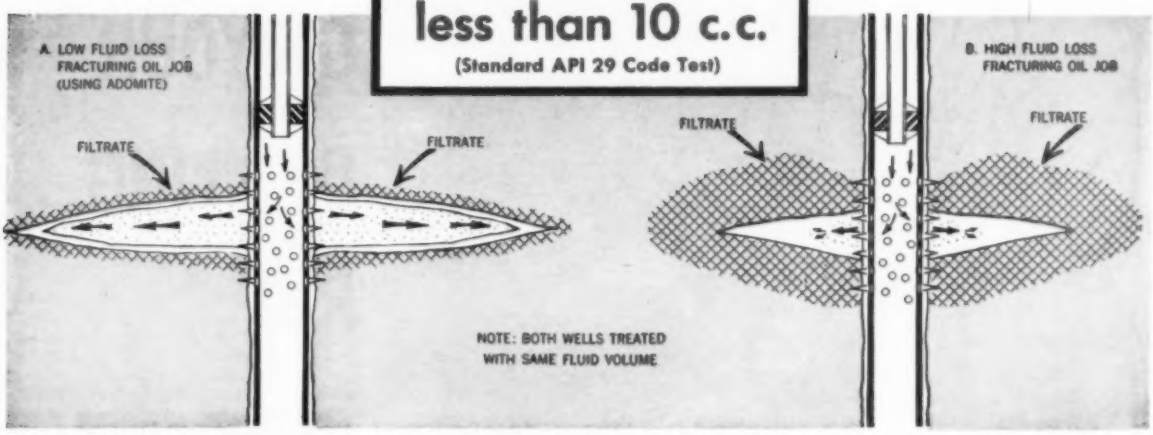
35 years OF OIL TOOL LEADERSHIP

For more productive fracturing . . . least fluid loss

specify Adomite

Cuts fluid loss to less than 10 c.c.
(Standard API 29 Code Test)


A. LOW FLUID LOSS FRACTURING OIL JOB (USING ADOMITE)
FILTRATE
FILTRATE
NOTE: BOTH WELLS TREATED WITH SAME FLUID VOLUME
B. HIGH FLUID LOSS FRACTURING OIL JOB
FILTRATE
FILTRATE

Adomite is the remarkable fluid-loss control additive that is building production and profits virtually everywhere it is used. Very small amounts of Adomite reduce the API fluid loss of lease crudes to 10 c. c. at most reservoir conditions. With gelled crudes, even smaller quantities are required. *Easy to use*, Adomite is a dry material in flake form that is mixed directly into the crude or gelled crudes on the lease. Only standard mixing equipment is required.

Only Adomite can do so many things so effectively . . .

- Seals the fracture face—minimizes fluid loss.
- Longer fractures—deeper penetration of sands.
- Greater sustained production with a given fluid volume at lower cost.
- Saves you money—utilizes lease crudes—less pumping.
- Cleans up quickly—does not contaminate produced oil or the formation.
- Fewer "Sandouts."
- Profitably used for "drilling in" and "work overs."

Be sure to specify Adomite on your next fracture job

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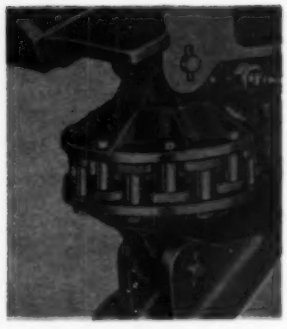
THAT MONEY IS MADE ON YOUR DRILLING RIG

Because it's right here....

that Martin-Decker instruments provide the driller with the information he needs to make better and faster hole. Weight indication, mud pressure, rotary torque, rotary speed, pump speed... *All* important and *all* necessary.



The Martin-Decker E-80 Sensater

This new kind of diaphragm pressure transformer works with your National Wire Line Anchor and transmits direct, no-lag signals to your Martin-Decker Type "D" or "E" Weight Indicator. The Sensater's rugged mobile diaphragm does not deflect, but moves with its backing plate to give a piston-like stroke without a friction-causing piston rod. Substantially unaffected by temperature and small fluid changes.

MARTIN-DECKER CORP.

HOME OF THE WEIGHT INDICATOR — LONG BEACH, CALIFORNIA

Martin-Decker Weight Indicators and National Wire Line Anchors are sold through the Reed Roller Bit Company, the National Supply Company, and other recognized supply houses, as well as by the Martin-Decker Corporation, 3431 Cherry Avenue, Long Beach 7, California.

RUNNING TOUR with MEN in the INDUSTRY

▸ **W. C. Goins Jr.** and **R. J. Goodwin** have been appointed heads of the drilling section and well completion section, respectively, in the production engineering

W. C. Goins Jr.

R. J. Goodwin

division of Gulf Oil Corporation's Research Center at Harmarville, Pennsylvania. In his new capacity, Goins will supervise research directed toward the development of new drilling techniques, both mechanical and chemical. Goodwin will direct research efforts on the improvement of well completion techniques.

▸ The following appointments have been named by Standard Oil Company of Texas: **G. W. Oliver** to a new position of chief evaluations geologist, production department, Houston; **D. P. Johnson** to division exploration superintendent, Oklahoma division, Pasotex Petroleum Company, Oklahoma City; **V. E. Tims** named division development geologist, eastern division, production department, Houston; **C. R. Hensch,** division exploration superintendent, northern division, exploration department, Dallas; **E. C. Masdon Jr.,** new position of assistant to chief development geologist, production department, Houston; and **G. L. Richards,** district geologist, Corpus Christi district, southern division, exploration department, Corpus Christi.

▸ **G. W. (Jerry) Bunce** has been appointed executive vice president of Arrow Drilling Company. He was formerly treasurer-controller.

▸ **Jack D. Swafford,** recently promoted to senior landman, is in charge of a new land office opened in Anchorage, Alaska, to handle General Petroleum Corporation's land department activities in the territory. **Paul Moody** has been promoted to district landman for the Rocky Mountain area replacing Swafford. Moody has been district leaseman for that area. **Richard K. Cramer** was named the company's junior landman for the Rocky Mountain area.

▸ **E. D. Whitis** has been appointed vice president, oil and gas division, of Ada Oil Company, Houston.

Whitis joined Ada in early 1954 as a reservoir engineer. In January 1957, he was put in charge of co-ordinating the land, geological and production activities of the company.

▸ **Hugh H. Beach** has been appointed assistant to the vice president of The Texas Company's domestic producing department. He succeeds **S. A. Berthiaume,** who was recently named vice president and manager of the Texaco Exploration Company, Calgary, Canada. Dr. Beach, formerly chief geologist of the department in Houston, Texas, will have his headquarters in New York.

J. A. Rogers, who began his career as a junior geologist around Wichita Falls, Texas, 21 years ago, has been promoted to chief geologist, general manager's office of Texaco's domestic producing department, with headquarters at Houston. Since April 1956, Rogers has served as senior geologist in the general manager's office at Houston.

▸ Kern County Land Company, a California corporation, has opened a Permian Basin district office in Midland, Texas, for petroleum exploration and development activities. **Donald G. Cook,** formerly a geologist with the Midstates Oil Corporation in Midland, Texas, has been employed as district supervisor in charge of the Midland offices. The Kern County Land Company is associated with the Monterey Oil Company in petroleum exploration and development in South Louisiana and the Permian Basin.

▸ British-American Oil Producing Company, Dallas, has announced the promotion of **George M. Binegar** to the post of manager of its employees relations department.

Binegar, who will serve in the same capacity for Toronto Pipeline Company, a subsidiary, has been assistant manager for the department since 1954. He joined British-American in 1950 following associations with Barnsdall Oil Company and later with Sunray Oil Corporation after the merger of the firms.

▸ **James Gardner** has been named contract representative of the Graham-Michaelis Drilling Company of Wichita, Kansas, for Oklahoma and the Texas Panhandle fields. He was formerly vice president of the Osage Oil and Gas Company.

modern sea castle to probe hidden depths

Ingalls-built Rig for Louisiana-Delta to Increase Efficiency of Undersea Drilling

New economies and greater efficiency are expected from the many new features built into this recently launched submersible drilling barge designed by Friede and Goldman and built by INGALLS for Louisiana-Delta Offshore Drilling Corporation.

Specifications include: Streamlined scour resisting hull measures 180′ x 151′, by 12′ depth. Designed to drill in water 65′ deep. Will provide accommodations for 44 men. Fitted with 140′ folding mast with 1,000,000 lb. capacity. All exposed sections specially coated to prevent corrosion. Built-in pumps will raise or lower barge. Helicopter landing area above deck house. Power for drilling equipment is supplied by diesel-powered generators.

Consult INGALLS *for design, construction or repair of floating equipment.*

THE INGALLS SHIPBUILDING CORPORATION

Executive Offices: Birmingham, Alabama
Shipyards: Pascagoula, Mississippi (Two yards on the Gulf)
Decatur, Alabama (On the Tennessee River)

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Running Tour

Bryan C. Edwards has been named Canadian division gas superintendent of Pan American Petroleum Corporation. During the past year, he has been active in formulation of plans and design aspects of the Pembina Gas Conservation Project, and serves as chairman of several area committees as well as the joint area committee which is comprised of representatives of Pembina producers.

D. L. Kastner of Odessa, Texas, has been named assistant general superintendent in Cities Service Oil Company's production division. **E. L. Cralle** of Odessa, superintendent of the company's North Odessa production operations, has been promoted to assistant division superintendent at Odessa, to succeed Kastner.

R. S. Randerson Jr., has been named production department co-ordinator for Tennessee Gas Transmission Company at its Houston headquarters. He was formerly assistant production manager.

Named as petroleum engineer for the company's wholly-owned subsidiary, Chaco Petroleum, S. A., was **Morris E. Kittleson,** formerly production engineer for Merrill Petroleums, Ltd., Calgary, Canada. Kittleson has been assigned to the Chaco office in Cochabamba, Bolivia. **J. H. Hudgeons,** formerly district production clerk at Hobbs, New Mexico, for Tennessee Gas, has been assigned to Cochabamba as office manager for Chaco. Appointed office manager for the Tennessee Gas overseas department in Houston was **H. G. Irwin Jr.,** formerly division office manager for the company's Gulf Coast production division at Bellaire.

Robert H. Craft and **James F. Jungé** were named new directors of the Commonwealth Oil Refining Company, Inc.

Craft, of New York City, is the president of Chase International Investment Corporation, foreign financing subsidiary of The Chase Manhattan Bank. Jungé, of Jenkintown, Pennsylvania, is an independent petroleum engineer associated with Wellington & Woodward, industrial consultants.

Philip L. Dana has been elected vice president, J. M. Huber Corporation. Dana's election as head of the company's oil and gas division, located at Borger, Texas, fills the vacancy left by the death of C. Earl Blackburn on November 25. Dana previously served as chief geologist and assistant to the vice president, oil and gas division. He has been with the company since 1944.

P. L. Dana

J. R. Buck

J. Randolph Buck has joined Northern Natural Gas Company as senior reserves engineer in the reserves and availability section of the gas supply department. Prior to joining Northern he was an independent petroleum consultant in Dallas, Texas.

George Echols, scout for the Standard Oil Company of Texas, has been installed as president of the National Oil Scouts and Landmen's Association. He heads an executive board which is composed of **Walter Holley,** Shreveport, 1st vice president (Monsanto Chemical Company, Lion Oil Division); **J. B. Johnson,** Oklahoma City, 2nd vice president (Sohio Petroleum Company); **Charles R. Kelly,** Bismarck, 3rd vice president (Sun Oil Company); **Daniel Greene,** Mt. Vernon, Illinois, secretary-treasurer (Magnolia Petroleum Company); **George B. Ross,** Midland, editor-in-chief (Humble Oil and Refining Company), and **Kelly Scott,** Houston, immediate past president (Superior Oil Company).

American Natural Gas Company announces the organization of a new wholly-owned subsidiary, American Natural Gas Production Company. **Varnum B. Steinbaugh** has been elected president of the new subsidiary and **S. A. Womack Jr.,** has been appointed manager of operations. American Natural Gas Production Company has opened offices in the Oil Center, Lafayette, Louisiana.

Clark Baker has become land manager for W. E. Bakke Oil Company of Midland and San Antonio. He will be stationed at Midland. Baker was formerly located in Midland with Harper Oil Properties before moving to Roswell in January 1957.

H. C. McCarver has been named manager of exploration replacing **R. A. Stehr** for Seaboard Oil Company. Stehr has asked to be relieved of that responsibility for reasons of health, but will continue to act as special adviser to the exploration department.

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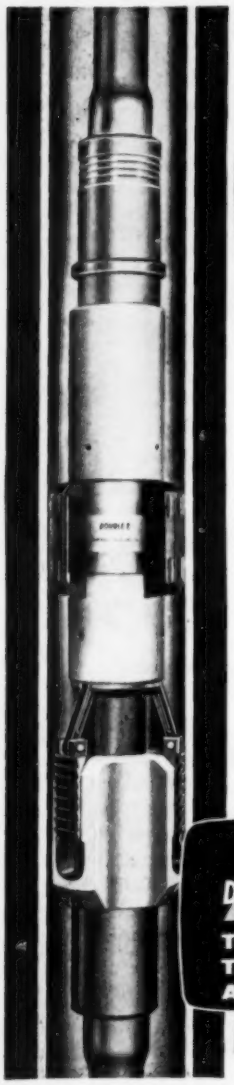

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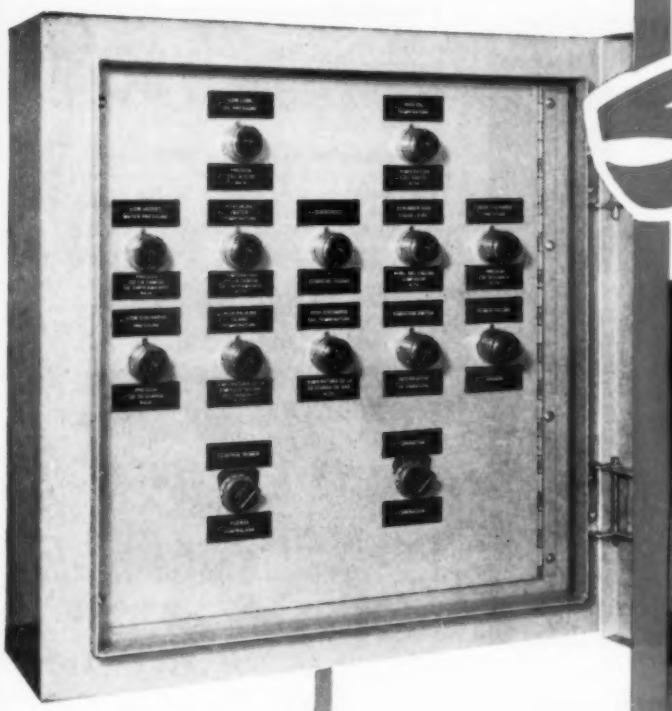

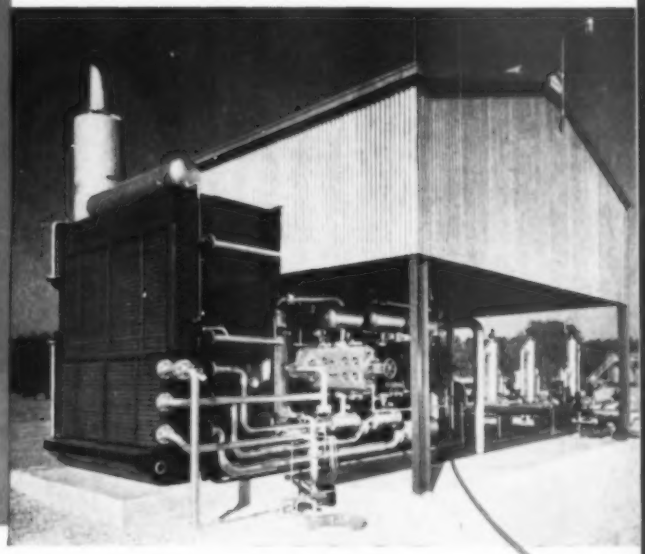

NOW THE NEW PANEL CONTROL FOR UNATTENDED COMPRESSOR STATION OPERATION

Southwest Packaged Gas Compressors can now be furnished with automatic shutdown and panelboard indicator equipment custom built to the particular requirements of your station.

Any combination of automatic shutdowns, working through a solenoid controlled valve in the fuel gas system, protects your engine against malfunction.

During normal operation, the signal lights on the panelboard remain off. When any one control switch becomes actuated due to abnormal operation, the signal light corresponding to that switch goes on. The engine shuts down automatically. All other relays are locked out, and the one signal light remaining on indicates the exact switch which caused the engine to shut off.

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As many as fifteen separate functions can be pinpointed by this panel indicator. Your maintenance men can get your compressor back on stream faster.

Southwest engineers will give you full details on this protective equipment for unattended compressor operation.

This is another development by Southwest to improve the operation of Packaged Gas Compressors.

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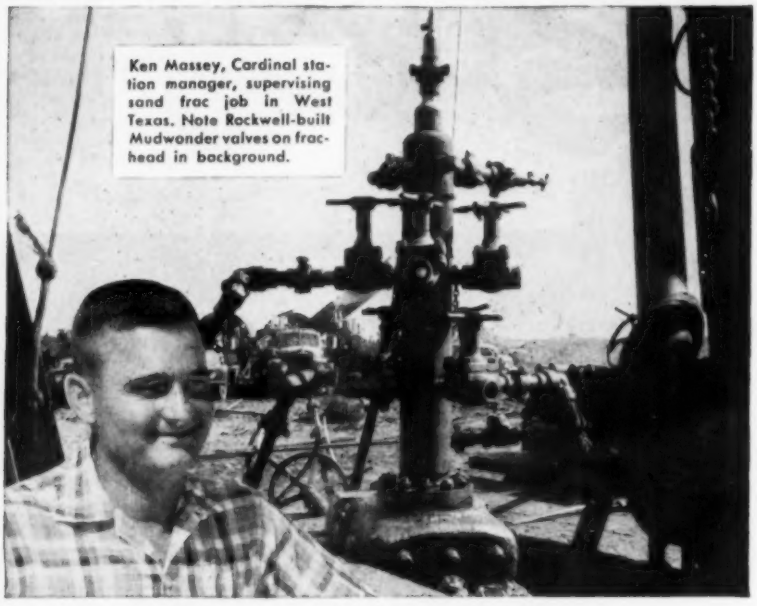
Tips on Valves for Service Companies..



Ken Massey, Cardinal station manager, supervising sand frac job in West Texas. Note Rockwell-built Mudwonder valves on frac-head in background.

We maintain sand frac fluid pressure with Mudwonder Valves!

by Kenneth Massey,
Odessa Station Manager
Cardinal Chemical Company

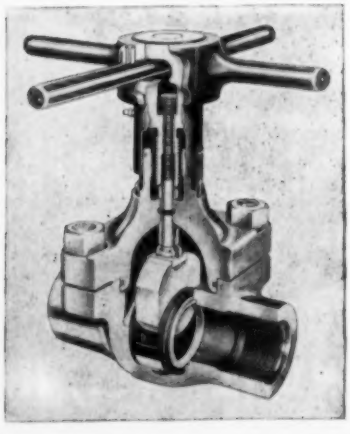
WE fracture oil wells. It's our job to get the maximum number of barrels pumped in the shortest possible time. That's why we use the best, most dependable equipment available—and drive it hard. When we finish pumping the sand frac fluid in under high pressure and close the well-head valves, we've got to be *sure* they don't leak. For two years now, we haven't had to worry. We find that well pressure never bleeds off when our Mudwonder valves are closed. There's no need to bump them shut or use a "cheater" to get drop-tight shut-off.

We now have 40 two-inch Mudwonders and several three-inchers. You might think maintenance would be a headache—but our Mudwonders don't seem to need much in the way of repairs. The only part that wears to any extent is the seat insert, which we can replace in a couple of minutes between jobs.

At the present time, we're using Mudwonders at all of our stations—Odessa and Levelland, Texas, and at Hobbs, New Mexico. We're thoroughly sold. Mudwonder valves are doing a great job for us, both on sand fracing and in acidizing.

Mudwonder valves are built in 2", 3" and 4" sizes; with screw or flange ends; for 2000 psi WP (4000 psi test) and 3000 psi WP (6000 psi test) service. See your favorite oil field supply store, or write Edward Valves, Inc., East Chicago, Indiana, subsidiary of Rockwell Manufacturing Company.

Mudwonder cut-away view shows the one-piece seat insert, with Buna-N molded integrally over steel wear rings; chromed gate with "T" slot connection; separated stainless stem and double thread construction.



Kenneth Cervenka has been named to the Midland, Texas, engineering staff of Tekoil Corporation. Cervenka, who will head the company's regional operations office in Midland, was associated with Shell Oil Company for five years prior to joining Tekoil.

James E. Gosline of San Francisco has been appointed to the post of director, vice president and assistant to the president of The California Company, headquartered in New Orleans. Calco is a wholly-owned operating company of Standard Oil Company of California. Gosline succeeds **Earl M. Kipp** who moves to California to assume Gosline's former position of special producing consultant on Standard's executive staff.

J. E. Gosline

J. H. Doughman

Jerry H. Doughman has joined Delhi-Taylor Oil Corporation in Dallas as chief petroleum engineer in the production division. Doughman started his career with a major oil company shortly after receiving a bachelor of science degree in petroleum production engineering from Tulsa University in 1940. He worked for several years in South Texas oil fields before transferring to Tulsa in 1945 as a reservoir engineer. In 1949, he was promoted to head secondary recovery engineer.

G. J. Kohler Jr. has been appointed vice president of Geophysical Service Inc. for geophysical operations in Latin America. **Ray H. Wright** has been named vice president of Geophysical Service International Corporation for Canadian geophysical operations.

Kohler formerly served as a division manager in Mexico. Wright has been Canadian area manager.

R. E. Warner, associated with Forest Oil Corporation for 28 years, has been appointed vice president in charge of primary production. Warner, a graduate of the University of Pittsburgh, joined Forest Oil at their home offices in Bradford, Pennsylvania, and was transferred to Texas in 1936.

Bayard B. Taylor has joined Kerr-McGee Oil Industries, Inc., as district landman in the company's Denver, Colorado, exploration offices. Taylor was employed as landman of The Texas Company and Western Gulf Oil Company in Los Angeles before becoming an independent broker in Denver.

C. V. Cameron has been named chief exploitation engineer for Shell Oil Company's Houston area. He moves up from the position of division exploitation engineer in the company's Houston division. Cameron replaces **H. J. W. ten Broeke,** who leaves for a foreign assignment.

Joseph Nalle has been elected vice president and petroleum engineer of Texas National Bank of Houston. Nalle became associated with the bank 2 years ago as petroleum engineer and assistant vice president.

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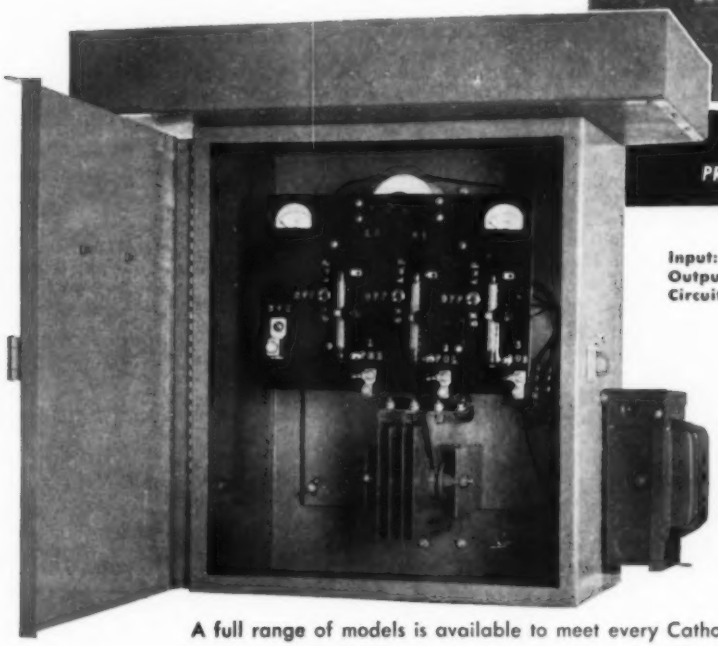

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Running Tour

▸ **William S. (Bill) Shropshire** has joined Falcon Seaboard Drilling Company as production engineer over Texas Operations. Shropshire was formerly district superintendent for Warren Petroleum Corporation at Big Spring, Texas. He now headquarters at the company's offices in Houston.

Bill Shropshire

P. V. Baker

▸ **Paul V. Baker** has been named safety director for the Gravey Drilling Company. Baker was formerly associated with Continental Oil Company for the past 12 years. He resigned his position as administrative assistant to their safety division in November to assume his new duties with Garvey Drilling Company. In his new position he will supervise a safety training program for the company's 250 employees and 17 rotary drilling rigs.

▸ **Michael J. Boyce,** superintendent of the Casper production division, Ohio Oil Company, has retired. He is succeeded by **H. J. Brunt,** assistant division superintendent.

▸ **James E. Gosline** of San Francisco has been appointed to the post of director, vice president and assistant to the president of The California Company, headquartered in New Orleans. Calco is a wholly-owned operating company of Standard Oil Company of California. Gosline succeeds **Earl M. Kipp** who moves to California to assume Gosline's former position of special producing consultant on Standard's executive staff.

▸ **T. L. Owen,** a veteran of more than 26 years in drilling, has been promoted from toolpusher to superintendent of the land drilling division of Rimrock Tidelands, Inc. The appointment of **G. D. Murray** to superintendent of the marine drilling division was also announced. He will be in charge of Rimrock's four offshore drilling rigs now operating in the Gulf of Mexico, as well as the company's two new barge mounted rigs which will begin operations later this year.

▸ **William C. Elliott Jr.,** formerly assistant chief of the Dallas offices of the Bureau of Mines, has been transferred to Wichita Falls where he will be chief of that office. Elliott is a graduate of the University of Oklahoma where he majored in petroleum engineering.

▸ **Kenneth E. Chaffin** has been made general superintendent of the Louisiana-South Texas division of Loffland Brothers Company, Tulsa, succeeding George C. Mallory, deceased. Chaffin was first employed by Loffland Brothers Company in 1936 and moved to that company's Louisiana Gulf Coast operations in 1938 where he has remained, with the exception of short periods in Canada and Cuba, until the present. For the past 3 years Chaffin has been superintendent of offshore operations. **D. E. Williams** has been promoted to assistant general superintendent of the Louisiana-South Texas Division. Williams began his career in the oil well drilling industry in 1941 when he joined Loffland. He has served in Louisiana, Mississippi, Venezuela, and Peru. Williams was made superintendent of land and inland barge operations in the Louisiana-South Texas Division in July of 1956, in which capacity he has been employed until his present promotion. Both Chaffin and Williams will make their headquarters in the company offices in New Iberia, La.

▸ **J. B. Storey** of United Gas Pipeline Company, has been elected a director of Union Producing Company, production subsidiary of United Gas. He was transferred to Shreveport on January 15 to assist in various production operations of the company. Story has been manager of the New Orleans district of United Gas and Union Producing since 1950. **R. G. Bryan,** assistant manager of the New Orleans district since 1956, will succeed Storey as district manager at that place.

▸ Monterey Oil Company announces the appointment of **Donlin P. Murdy** as vice president for finance and **Albert W. (Bob) Gentry** as vice president for operations. Murdy and Gentry have been promoted from assistant to the president and manager of field operations, respectively.

▸ **Paul L. Waid** has been made assistant superintendent of operations of Loffland Brothers Company of Canada. He entered the oil well drilling industry in March of 1943 with Loffland Brothers Company at Clay City, Illinois. Most of his experience has been gained in the Rocky Mountains area, and has had previous experience in both Alberta and Saskatchewan, Canada. Waid will make his headquarters in the offices of Loffland Brothers Company of Canada, in Calgary, Alberta.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Running Tour

▸ Latin America division offices for Sun Oil Company's foreign operations department, formerly located in Dallas, Texas, have been moved to Caracas, Venezuela. Involved in the move are **B. E. Warren,** division manager; **P. W. McFarland,** division chief geologist; **Lee C. Smith,** division assistant chief geologist; **John Waller,** district geophysicist; and members of their staffs.

▸ Appointment of two assistant general managers of The Texas Company's domestic producing department and the naming of two new division managers has been announced with several other personnel changes. **M. L. Terry,** division manager, Oklahoma division, takes early retirement, effective March 1. **H. O. Woodruff,** assistant general manager, Houston, will replace Terry as division manager, Oklahoma division, with headquarters at Tulsa. **S. T. McCardell,** assistant division manager of the Louisiana division, will be transferred from New Orleans to Houston to become assistant general manager, replacing Woodruff. **J. H. Markley Jr.,** assistant division manager of the West Texas division, will be transferred from Fort Worth to Houston to become assistant general manager. **Tom T. Freeman,** division manager of the Rocky Mountain division, is being transferred from Denver to the general manager's staff, Houston, as manager of land evaluations. **O. B. Hocker,** assistant division manager of the South Texas division, has been named division manager of the Rocky Mountain division and will move from Houston to Denver. **George H. Clark,** assistant to general manager, is being transferred to assistant division manager of the South Texas division, replacing Hocker.

▸ **J. D. Richardson** has been named division drilling superintendent for Pan American Petroleum Corporation's Rocky Mountain division headquartered in Casper Wyoming. Richardson moves to Casper from Pan Am's Houston, Texas division office where he had been drilling research engineer since 1953. He replaces **G. A. Isaacks,** who has transferred to Fort Worth, Texas.

▸ Monterey Oil Company has appointed **Ford M. Graham** of Hammond, Louisiana, as vice president and senior representative for the company in Louisiana and Mississippi. Graham, formerly an independent oil and gas operator, has served as consultant to Monterey and other producers for the past four years. He will direct exploration activities in the area from the company's offices in New Orleans.

▸ **Edgar Kraus** has been named assistant general manager of the domestic crude oil production department, Atlantic Refining Company. He has served as manager of the domestic producing exploration division since 1952. It was also announced that Kraus will move up to succeed **James N. Mendenhall** as general manager upon the latter's retirement within the next several months. **William B. Moore,** formerly manager of the company's South Louisiana producing region, has been named to succeed Kraus as manager of the exploration division. **Louis F. Davis** has been appointed to the new position of regional division manager, heading up the company's six producing regional divisions. He was formerly manager of the Oklahoma-Kansas region.

M. S. Jameson Jr.

▸ **Minor S. Jameson Jr.,** a member of the Independent Petroleum Association of America staff since 1937, was elected executive vice president and was designated to coordinate departmental activities and the overall program of the association. **Russell B. Brown,** general counsel for the association since 1930, will continue to be responsible to the president in his top policy position as head of the association's legal department, responsible for its governmental relations activities. Jameson, in addition to his duties as executive vice president, will continue in direct charge of the association's economic and statistical department. His advancement to executive vice president fills a vacancy created in 1955 by the retirement of **Harold B. Fell,** who held that post for almost a quarter century.

Other departments established include: Administration and finance, which has charge of all business and financial affairs of the association under **I. C. Huff Jr.,** executive manager and secretary. Membership department, headed by **B. H. Vickrey** as membership director, and staffed by four district representatives who maintain liaison with IPAA members in all producing areas of the nation. Information department which has responsibility for planning and coordination of both public and industry information activities under **Lloyd N. Unsell,** director of information.

▸ Creation by Tennessee Gas Transmission Company of a new Mid-Continent division oil and gas production headquarters in Oklahoma City was announced with **J. P. Schmalz** to head the new office, as division production manager. He formerly occupied a similar position at the company's Central division headquarters at Midland, Texas. Other personnel assigned to the Oklahoma City division include **H. E. Rowe Jr.,** division petroleum engineer; **Willian Miskimins Jr.,** production foreman, and **W. F. Lewis,** division production office manager.

A number of other personnel reassignments were announced. These include **J. P. Jacks,** as division production manager at Midland, replacing Schmalz; **L. B. Plumb,** as division petroleum engineer at Midland; **L. C. Bodemann Jr.,** division petroleum engineer at Denver, Colorado; **J. L. King,** division production office manager at Denver; **L. P. Miller,** district petroleum engineer at Oklahoma City, and **E. L. Patterson,** district clerk at Wichita Falls.

▸ **Robert L. Breedlove,** of Shreveport, Louisiana, has been promoted to the position of chief geologist for Arkansas Louisiana Gas Company. Breedlove has been serving as acting chief geologist for Arkansas Louisiana since early in 1957. He has been connected with the geological department of ALG and its predecessor companies since July 1935.

▸ **Hal F. Nabors,** Oklahoma City, has been promoted to general manager of Continental Oil Company's central region. He will continue to make his headquarters at Oklahoma City. He has been acting regional manager since March 1957.

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'Extreme Pressure' Lubricated Mud

Gulf develops drilling mud additive with extreme pressure lubrication properties; tests show bit wear reduced 2 to 5 times, rotating torque 1/20 of conventional mud

A drilling mud additive has been developed that promises to adequately lubricate drill bit bearings and the hole — with the end result of less bit wear, fewer trips, reduction of drill pipe fatigue, and lower rotating power requirements.

The additive is a result of efforts by Gulf Oil Corporation scientists, who developed, lab and field tested it extensively.

The tests indicated the additive increases the life of drill bits by two to five times, and reduce to an equal extent, the frequency with which the drill string must be pulled out of the hole to change bits.

In deeper wells, where round trips account for 20 to 40 percent of rig time, Gulf achievement is expected to cut trip time in half.

Numerous Advantages Cited

Several related advantages are expected to contribute substantially to lower drilling costs:

Number of bits per well may be cut in half or more. The most commonly used rock bits range in price from $150 to $1200, the higher figure for the carbide bits used in the hardest formations. For a 10,000-ft well in hard formation 100 to 150 bits would normally be used.

Wear on drill pipe and on the rig would be reduced, due to less frequent round trips, which subject both to heavy strains. Also, the new mud is said to lessen friction throughout the hole to the extent that less wear on pipe and rig occurs during withdrawals and while drilling.

Lost tools and pipe could be more easily recovered due to less friction.

Reduction of friction in the hole, would lessen reduction of power requirements for rotating the drill string.

Drill pipe rotating torque measured on several test wells using the lubricating additive in the mud dropped as low as 1/20 of that with conventional muds, Gulf reports.

Application has been made for comprehensive patents covering the Gulf development, which will be licensed to mud service organizations. Amounts of the extreme pressure lubricant additive used in the mud to obtain the above results are relatively small and inexpensive, it was stated.

Research

Some 3600 tests of mud formulations were first made on a machine, the first testing ever made of drilling mud for extreme pressure lubricating qualities. Conventional oil emulsion mud showed only minor lubricating quality on the machine; but when EP additives were introduced, the load-carrying characteristics of the resulting mud mixture rose to surprisingly high values.

Lab Tests

To substantiate these far-reaching implications, pilot tests were run on a full-scale drilling rig at the Gulf Research Center. Commercial bits were used, boring into steel blocks flooded with the mud under test. The results closely correlated with those of the test machine, showing two to five times longer bit life with drilling mud containing EP additives.

The pilot trials established an overall average of 18 bit life hours before failure for bits when run with conventional muds, compared to 55 bit life hours for bits run with the same muds with EP additives. A few of the specific pilot test results follow:

Conventional oil emulsion mud, 20 life hours; with EP, 60 life hours. Conventional 6 percent bentonite mud, 10 hours; with EP, 55 hours. Conventional clay and water, 15 hours; with EP, 65 hours. Conventional weighted mud, 11.5 lb per gal, 38 hours; with EP, 78 hours.

Field Trials

Next came field trials. In a comparative test in West Texas, a bit with a conventional mud ran 17¾ hours and made 344 ft before failure; while in a similar formation nearby the same type bit with the same mud plus EP additives, ran 41 hours and made 915 ft.

Other West Texas tests were made in harder formations with the tungsten carbide insert bits usually employed for this type drilling. With conventional muds, "locking" of the cones occurred within 15 to 50 hours, the average time being about 25 hours. With EP muds under the same drilling conditions, the average bit life was about 100 hours and one of the bits drilled 1200 ft in a hard dolomite formation. ★ ★ ★

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CF&I SEAMLESS casing and tubing

THE COLORADO FUEL AND IRON CORPORATION • DENVER, COLORADO

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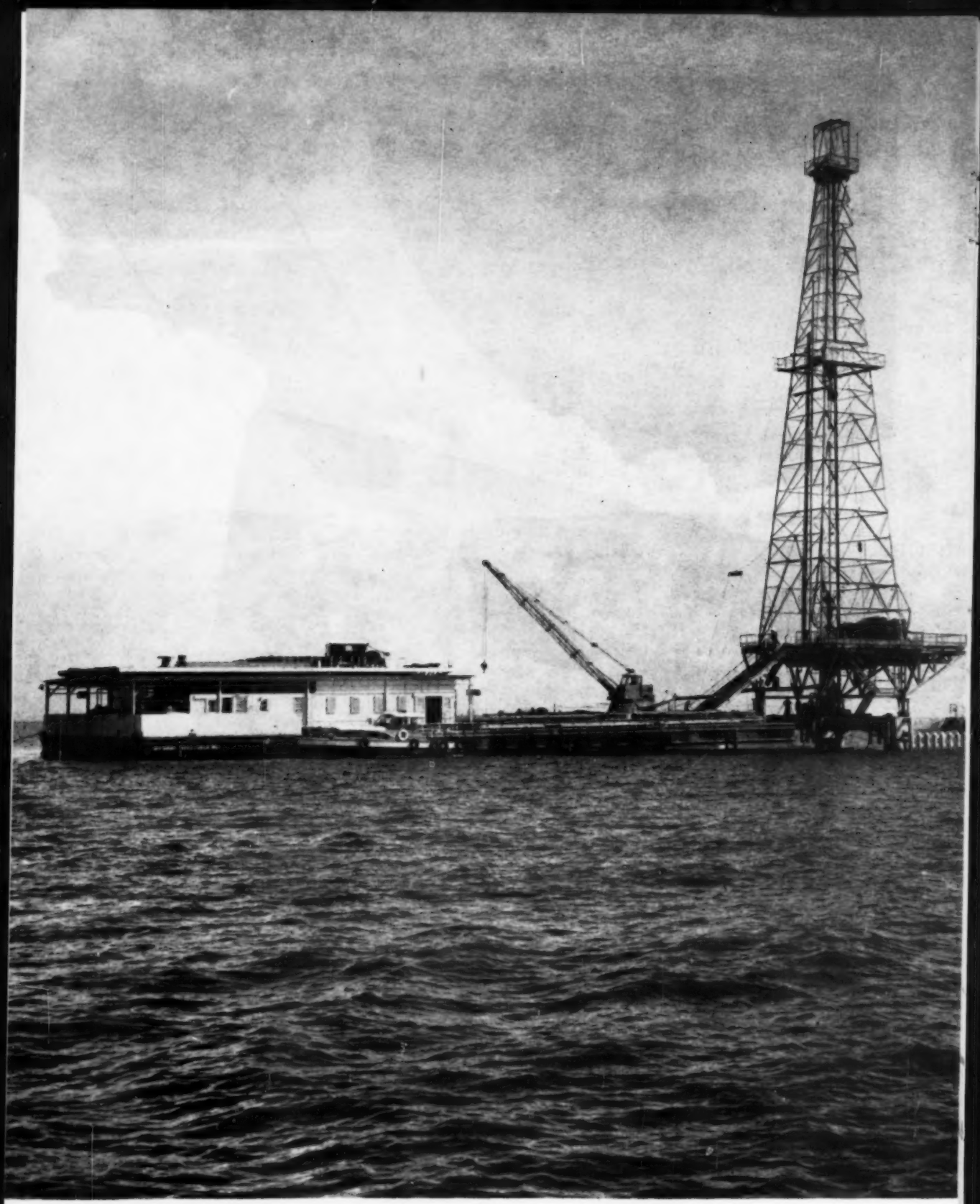
B-161



Drilling in Lake Maracaibo is The Offshore Company's new barge V-1. Barge V-2 is also working in this area. These units are the most powerful Diesel-electric rigs yet to work in Venezuela. Each is capable of drilling in excess of 12,000 feet.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

B-161

The Offshore Company Goes to Venezuela

—picks Electro-Motive Power with overseas service and parts facilities for two new Diesel-electric barges

The Offshore Company, first to use Electro-Motive Power in the United States, is now first to use this Diesel-electric equipment in Venezuela on their new barges, V-1 and V-2.

Each of these modern barges contains Electro-Motive equipment of 2700 horsepower, making them the most powerful Diesel-electric rigs sent to work in the Lake Maracaibo area.

Behind The Offshore Company's choice of power for the new barges was experience with Electro-Motive Power on their record-breaking mobile platforms Nos. 54 and 55 and their fixed platform No. 25. But most important was the knowledge that they could get *local* service for Electro-Motive equipment from General Motors de Venezuela.

Factory-trained personnel head up this facility through General Motors Overseas Operations. It offers the same superior service for Electro-Motive equipment found in the Gulf. Here too, complete facilities are offered for both engine and electrical components—*one responsibility* for the complete power system.

If your interests lie in moderate or deep drilling in this country, Canada, South America, or elsewhere, look into the advantages of Electro-Motive equipment with established world-wide service facilities. See your Electro-Motive representative for details.

ELECTRO-MOTIVE DIVISION
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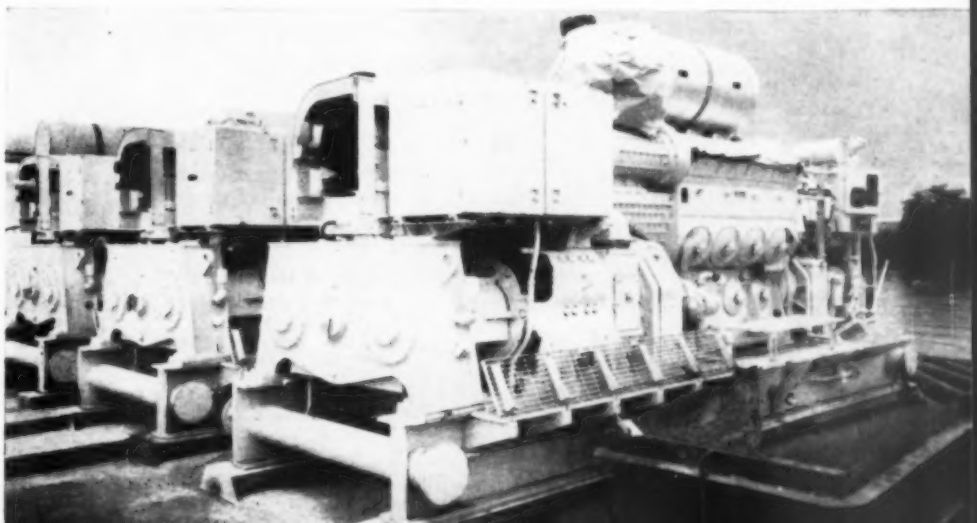
In Canada: General Motors Diesel Limited, London, Ontario
Petroleum industry sales offices: Dallas and Houston, Texas; Morgan City, Louisiana; Los Angeles, California.



Three Electro-Motive engine-generator sets of 900 hp each supply power to drive motors on mud pumps and draw works. These sets are heat-exchanger cooled. Sets are also available with air cooling or keel-cooling systems.

drilling in excess of 12,000 feet.

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McCullough Bullet Gun Proves Fracturing Power

M-3 Bullet Gun Assures Successful Completion of Fracturing Job...Penetrates and Cracks Tough Formation After Other Bullet Gun Failed

Previously perforated with bullets by another service company, the operator was unable to fracture the formation in this Illinois well. Pump pressures to 4000 psi were reached without results.

McCullough was called to reperforate the well with the 4⅛" OD M-3 Bullet Gun. Twenty improved ½" Ogival Bullets were shot through 5½" 14 lb. J-55 cemented casing in a five foot interval from 2833′ to 2838′.

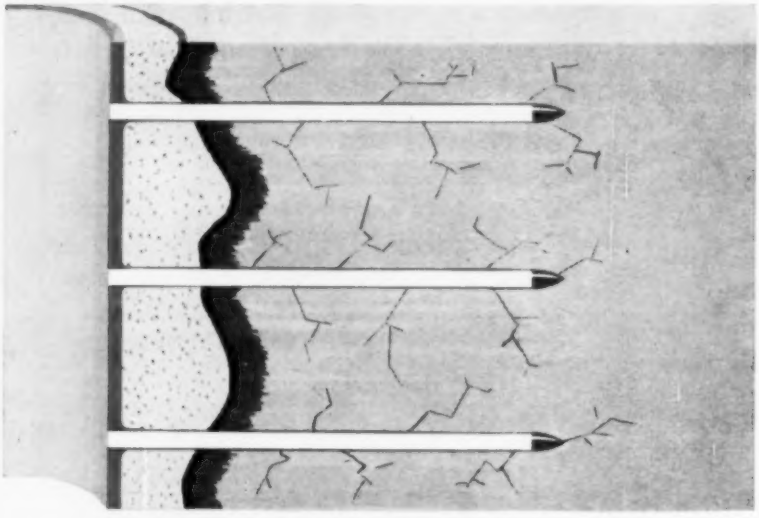
After perforating by McCullough, the formation broke down at 1600 psi and took fracturing material at the rate of 350 gallons of oil and 700 pounds of sand per minute. The well is now flowing – one of the best in the field – and entire perforating job required only 1½ hours rig time.

McCullough M-3 Bullet Guns and improved Ogival Bullets have always given you deeper penetration and superior formation fracturing ability. These features have proved invaluable where tough, tight formations must be further fractured under pressure for peak production.

And proof of this superior ability of M-3 Bullet Guns is in their long record of jobs successfully completed – after others have failed.

Next time, be sure of results – call McCullough first.

The job described above is certified by a true field report of services rendered.



M-3 BULLET GUNS GET DEEPEST PENETRATION GREATER FRACTURING POWER

Size for size, McCullough M-3 Guns consistently outshoot all other bullet guns. They give you deepest penetration even through excessive thicknesses of casing and cement. They fracture the formation better than other bullet guns because they shoot harder. M-3's consistently get better results – peak production; more oil!

M-3 Bullet Guns have proved superior to other types of bullet and jet perforating under nearly all well and formation conditions encountered.

McCullough® TOOL COMPANY

Cable Address: MACTOOL

LOS ANGELES
HOUSTON
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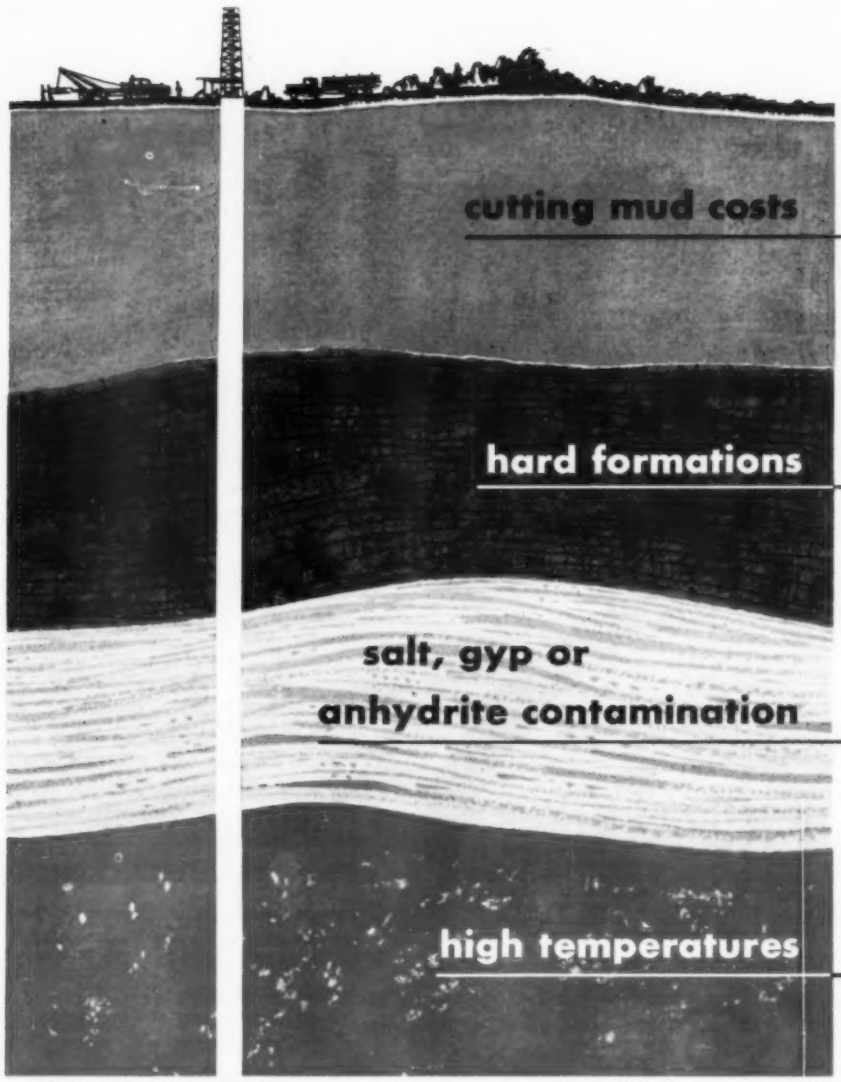
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Du Pont CMC (Grade DM) costs less than highly purified grades which exceed most drilling needs. Without the premium price, you get excellent fluid loss control, good weight suspending properties.

For a good oil-in-water, low solids mud, use a little Du Pont *high viscosity* CMC in place of a lot of bentonite. By holding clay solids to a minimum, you get a "fast drilling" mud which requires a minimum of chemical treatment.

When Du Pont CMC is used as a clay replacement, the undesirable effects normally resulting from an encounter with salt, gyp, or anhydrite, are minimized. Costly rig time for mud conditioning is reduced.

Your muds hold up, even at extreme depths, when you use Du Pont CMC because of its resistance to thermal and bacterial degradation.

Offshore or onshore, drillers report saving as much as 50% in dollars-per-foot costs by using Du Pont CMC in their muds.

How Du Pont CMC solves these mud problems ...at rock-bottom cost

DU PONT
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DU PONT CMC
FOR DRILLING MUDS

Better Things for Better Living . . . *through Chemistry*

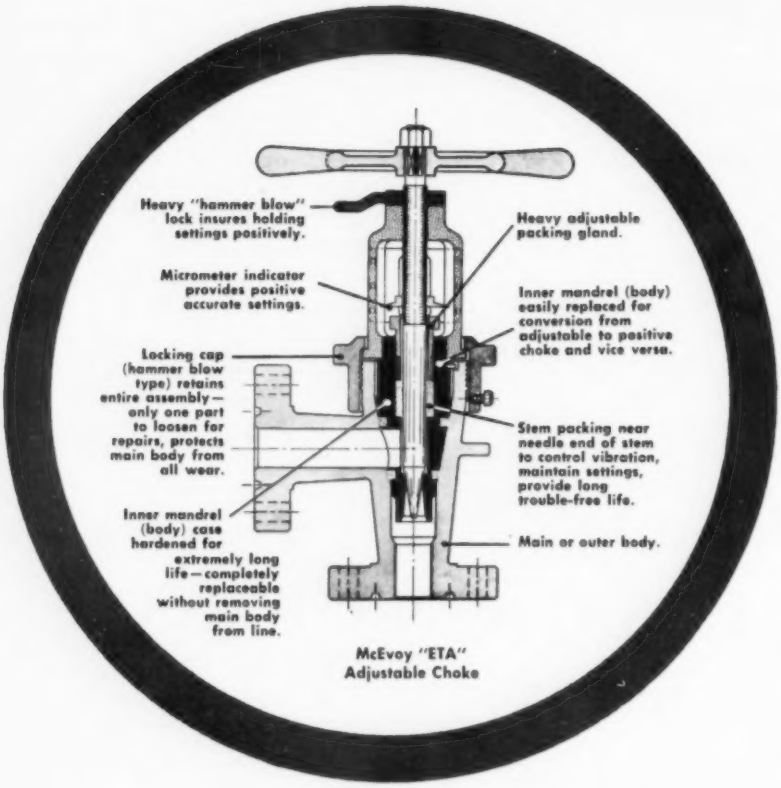
Your local mud dealer can introduce you to these and other advantages of Du Pont CMC (low viscosity or high viscosity) **immediately.** Or contact:

- **Barada & Page, Inc.**, offices in Corpus Christi, Dallas, Fort Worth, Houston, Kansas City, New Orleans, Odessa, Oklahoma City, Tulsa, Wichita.
- **Macco Corp.**, Paramount, California.
- **Du Pont Explosives Department,** offices in Dallas, Los Angeles and Wilmington.

See the "Du Pont Show of the Month" on CBS

to the contractor . . .

CONTROL preventer manifolds with McEVOY "ETA" chokes


Heavy "hammer blow" lock insures holding settings positively.
Micrometer indicator provides positive accurate settings.
Locking cap (hammer blow type) retains entire assembly—only one part to loosen for repairs, protects main body from all wear.
Inner mandrel (body) case hardened for extremely long life—completely replaceable without removing main body from line.
Heavy adjustable packing gland.
Inner mandrel (body) easily replaced for conversion from adjustable to positive choke and vice versa.
Stem packing near needle end of stem to control vibration, maintain settings, provide long trouble-free life.
Main or outer body.

McEvoy "ETA" Adjustable Choke

McEvoy "ETA" chokes comply with API standards and are available in alloy or 12-14 chrome MACALOY stainless steel with K-Monel stem . . . in working pressures from 2000 to 10,000 psi. Adjustable or positive with flanged inlets and outlets.

McEvoy "ETA" chokes feature a *replaceable inner mandrel* which protects the main body, takes all wear and prevents high pressure fluids and gasses from damaging the main outer body . . . assuring the contractor the longest choke-life possible.

Proven through years of service in the world's most damaging installations, the McEvoy "ETA" choke was specifically made to withstand the highest temperatures and pressures of deep gas injection wells where all other types of chokes failed.

The "ETA" performance was so outstanding that it won a permanent place in the McEvoy line of proven products. It is now available for installation on every well, under all conditions. The McEvoy "ETA" is a proven money-saver. It is designed for quick tear-down without removal from the line, fast field conversion from adjustable to positive or vice versa, and long-life operation.

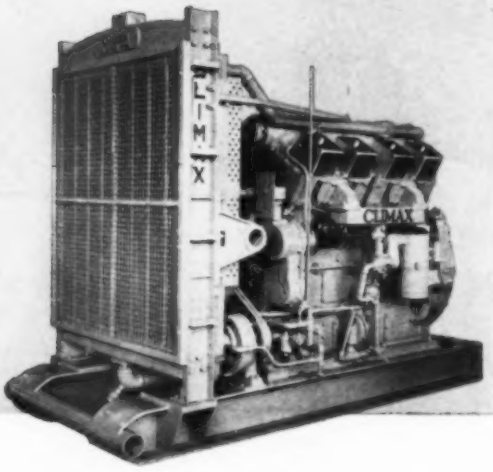
It will pay you to investigate and use these outstanding chokes. Write for details.

McEvoy COMPANY
OIL WELL EQUIPMENT
Texas and Milby Streets
P. O. Box 3127
Houston 1, Texas

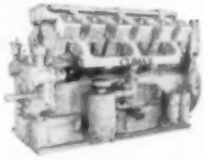
THE BIG FEATURE ABOUT CLIMAX ENGINES

IS THE OWNER SATISFACTION

THEY PROVIDE . . . .



A Complete Line of Oil Field Engines up to 605 H.P.

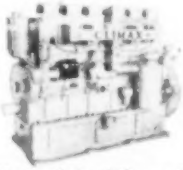


V-125—12 cylinder, 605 max. H.P. at 1200 R.P.M.

V-122—12 cylinder, 520 max. H.P. at 1200 R.P.M.

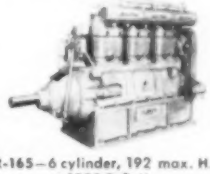
V-85—8 cylinder, 390 max. H.P. at 1200 R.P.M.

V-80—8 cylinder, 340 max. H.P. at 1200 R.P.M.



K-75—6 cylinder, 302 max. H.P. at 1200 R.P.M.

K-67—6 cylinder, 265 max. H.P. at 1200 R.P.M.



R-165—6 cylinder, 192 max. H.P. at 1200 R.P.M.

. . . MIGHTY IMPORTANT TO CONSIDER WHEN YOU BUY AN ENGINE!

Here's why Climax Engines are so "owner satisfying"—

You get an engine that will give years of service on any job . . . whether powering drilling rigs, pumps, compressors or generators.

—an engine designed for easy starting . . . simplified operation . . . equal efficiency on natural gas, butane or gasoline by merely closing one set of valves and opening another . . . easy maintenance . . . readily accessible operating parts and accessories.

—an engine backed by prompt service throughout the oil country . . . friendly Climax Distributors offering a complete stock of parts, repair facilities and factory trained mechanics.

—these, plus many other Climax advantages, add up to owner satisfaction . . . the kind you get when you buy Climax Engines!

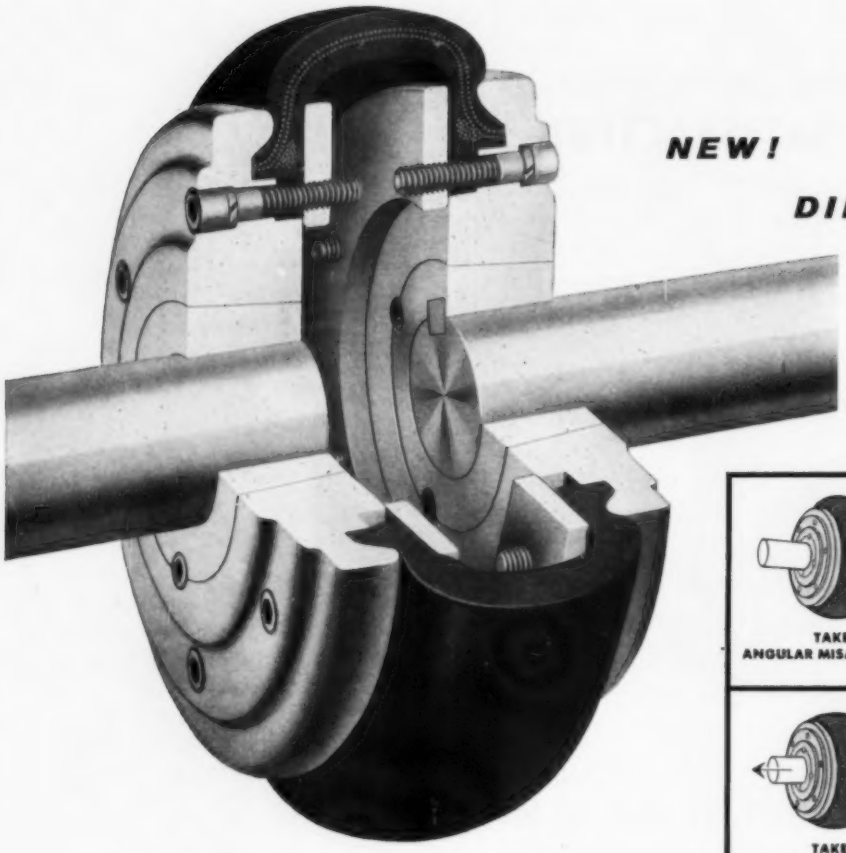
See, call or write your nearby Climax Distributor today!

CLIMAX ENGINE MANUFACTURING CO.

DIVISION OF WAUKESHA MOTOR COMPANY

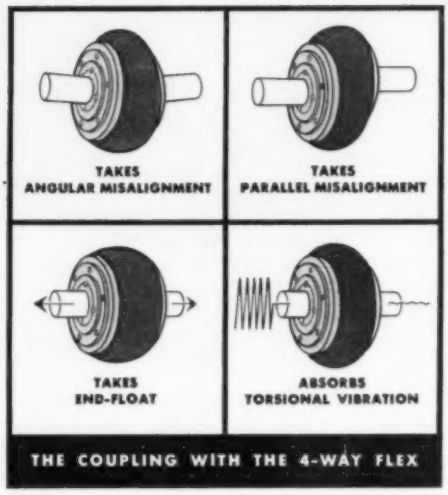
•

FACTORY—CLINTON, IOWA



NEW!

DIFFERENT!



DODGE

Para-flex

FLEXIBLE CUSHION COUPLING

THIS coupling "swallows up" shaft misplacements. It automatically compensates for end-float, parallel misalignment, angular misalignment *or any combination of all three.* Moreover, it cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

Here is a new type of performance—made possible by the development of a tire-like flexing element. Synthetic tension members, bonded together in rubber, give this element the stamina and dependability of modern, high-speed, high-load, shock-absorbing truck tires—and the ability to respond magically to all manner of changing shaft conditions.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. No lubrication is required, no periodic inspection. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine.*

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 825 hp at 1200 rpm. Call your distributor for early delivery to *make your own test.* You'll witness something revolutionary!

DODGE MANUFACTURING CORPORATION, 7900 Union, Mishawaka Ind.

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

Your Well Is Safe With

RECTORHEADS

the head that seals with the Ring-of-Steel

More than 125,000 Rector casing head installations prove that you can forget about pressure leaks when your well is equipped with Rectorheads. For working pressures to 15,000 psi . . . regardless of temperature extremes . . . the Rector ring-of-steel provides a lifetime seal.

There is no resilient packing to flow under pressure or deteriorate from heat or time. The casing is welded to a steel ring that fits in a precision ground seat. There is no stress on the weld when the flange bolts are tightened. A steel API ring gasket completes the permanent, maintenance-free seal.

For well safety and long range economy, specify RECTORHEADS . . . now in sizes through 20". Order from your favorite SUPPLY STORE.

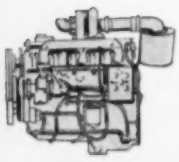
RECTOR WELL EQUIPMENT COMPANY INC

★ MAKING THE OIL INDUSTRY SAFER

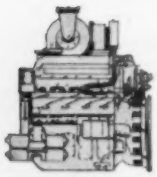
1100 NORTH COMMERCE ST. FORT WORTH, TEXAS

Houston Plant: 2215 Commerce St.

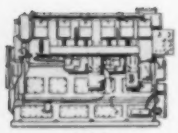
EXPORT REPRESENTATIVES: Continental Supply Company • Mid-Continent Supply Company • Oil Well Supply Company



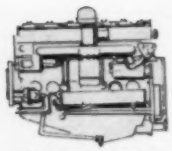
CUMMINS



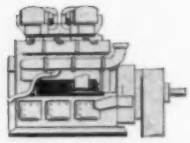
HERCULES



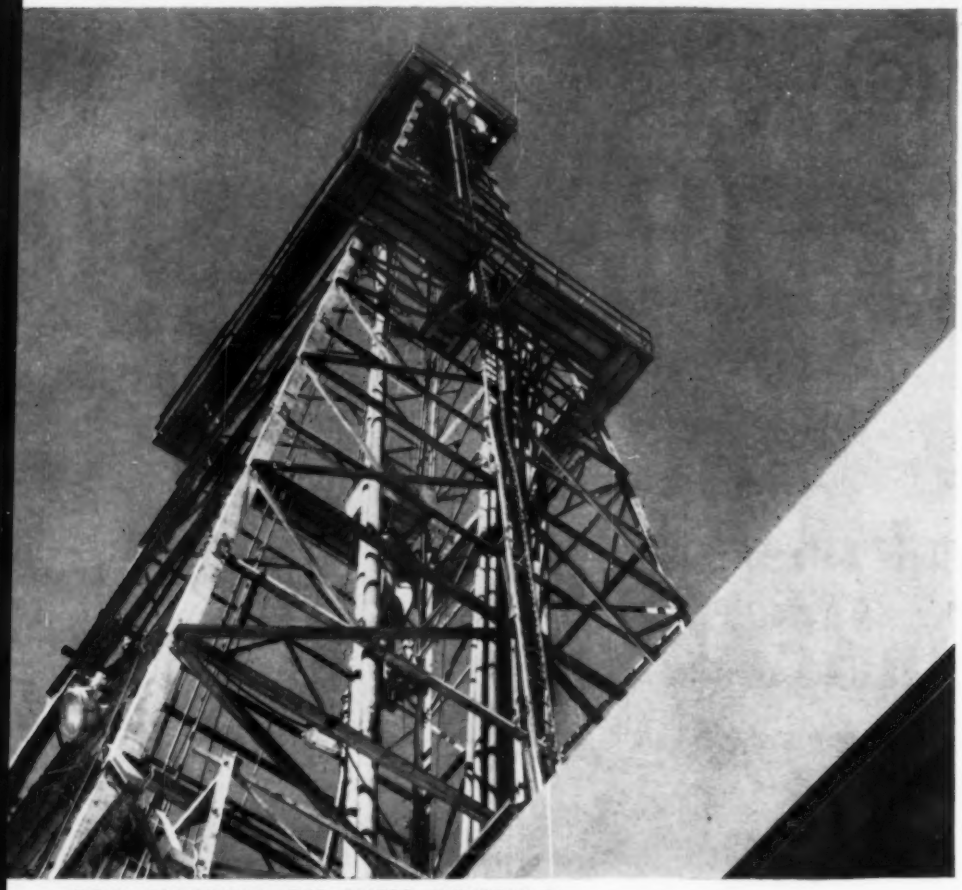
CLIMAX

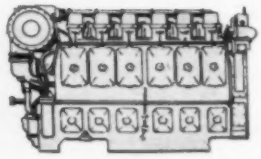


MURPHY DIESEL

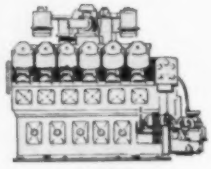


HALL-SCOTT

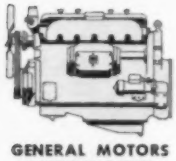




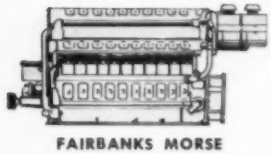
ALCO



LEROI



GENERAL MOTORS
DETROIT DIESEL



FAIRBANKS MORSE

FOR ELECTRIC OIL WELL DRILLING . . .

Use Your Favorite Engine With General Electric Drive

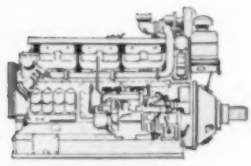
Your preference for a particular make of oil field engine (several makes are shown above) need not be sacrificed to gain the benefits of electric oil well drilling. You can use G-E drive with the same types of engines you may have been using without changing your existing engine stocking and parts procedures . . . without subjecting your personnel to new engine operation and maintenance training.

GENERAL ELECTRIC DRIVE IS AVAILABLE IN MANY SIZES for a wide range of applications. Designed-in control simplicity eliminates complicated external apparatus, feedback systems, and torque limiting devices. G-E drilling generators eliminate the need for current and voltage regulating controls. G-E's familiar air throttle system eliminates individual exciters for each generator and G-E drilling motors will not run away in case of load loss.

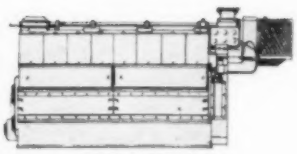
GENERAL ELECTRIC AND THE ENGINE BUILDER WORK TOGETHER to furnish you with a completely coordinated system suited to your drilling needs.

FOR MORE INFORMATION, call your nearest G-E Apparatus Sales Office. Drilling offices are in Dallas, Denver, Houston, Los Angeles, New Orleans, and Tulsa; in Canada: Calgary and Toronto. For overseas requirements, International General Electric drilling offices are in Bogota, Buenos Aires, Caracas, Maracaibo, Mexico City, New York, and Puerto LaCruz.

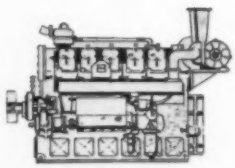
115-24



CATERPILLAR®



WHITE-SUPERIOR



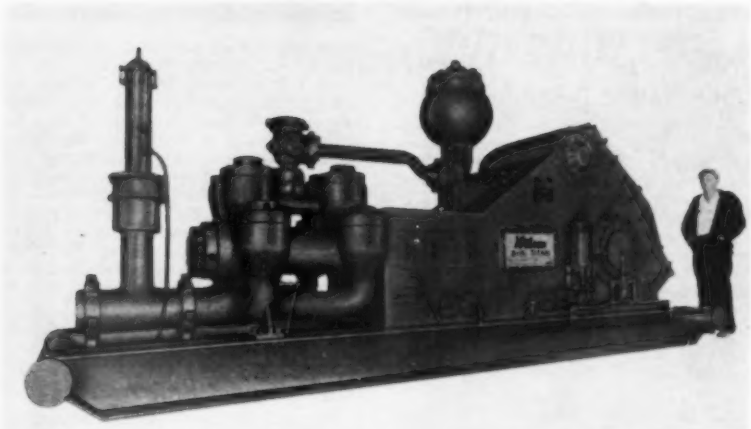
WAUKESHA

GENERAL ELECTRIC

It's New

Drilling – Producing Equipment

1250-hp Slush Pump Weighs Only 35,300 lb



A new giant slush pump, weighing only 28 lb per hp, has been announced by Wilson Manufacturing Company. Weighing only 35,300 lb and delivering 1250 hp, it is the lightest pump per horsepower yet built.

This pump features Wilson's unique chain drive. The powerful quadruple roller chain with an 8-to-1 safety factor provides ample strength for all normal operations, yet it is still the weakest link of the unit and will break before the rest of the pump will fail.

Main rods and pony rods are equipped with tapered threads which allow them to be made up absolutely tight and yet be easily removed. The crank is a true crank, and is smaller, lighter and more efficient than an eccentric type pump. The all-steel frame is made of shape-cut plates and steel castings, providing great strength with light weight.

The removable stuffing box can be replaced without removing the cylinders from the frame. Valve covers and cylinder heads are quickly removable. All wearing parts are replaceable. Moving parts in the power end of the pump are pressure lubricated by a rotary pump, driven by a chain drive from the pinion shaft. All lubricating oil is continuously strained and filtered.

Wilson has prepared an informative booklet covering the specifications and operation of the Titan 8 by 18 in. pump, including a table showing pump capacities operating with liners from 5½ in. to 8 in. and at speeds from 40 to 75 strokes per min. The booklet also includes illustrations and descriptions of the many features of the pump. *Wilson Manufacturing Company, Inc.*

Circle number (1) on reply card.

Pipeline Insulator

A new plastic insulator, said to be impervious to moisture, corrosion and decay, has been developed by the F. H. Maloney Company. According to the manufacturer, it represents a new concept in plastic pipeline insulators because it combines strength with long life and ease of installation at a competitive price.

Designed to absorb load shocks and provide cathodic protection at pipeline crossings, the insulator is available in size ranges from 2 through 36 in. Composed of glass fiber reinforced polyester, it is compression molded at high temperature and pressure. It is ribbed inside to prevent cold flow of the pipe wrap and has been tested in excess of 18 tons and temperature tested in excess of 400 F in boiling pitch. *F. H. Maloney Company.*

Circle number (2) on reply card.

Slush Pump Rod Oiler

The S. R. Bowen pump rod oiler provides a simple, effective and trouble-free method of lubricating slush pump rods. It is applicable as original lubricating equipment on new slush pumps, and as a replacement for defective or worn out lubricators on pumps now in the fields. This self-priming unit furnishes a constant flow of clean oil on the rods to keep them free of abrasive elements and provides a film of lubricant between moving parts.

It is activated by the piston rod cross head nut or a flange on the pump rod and will move the oil from a reservoir below to the accumulator tank above from where it is fed to the pump rod, and then returned to the reservoir. *S. R. Bowen Company.*

Circle number (3) on reply card.

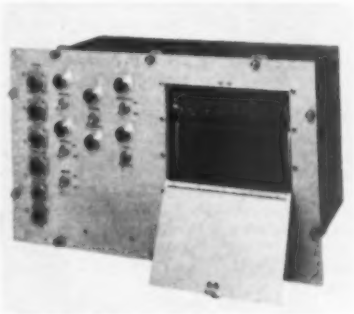
Low Voltage Lighting Sets

New lighting sets provide 200 to 400 w of grounded illumination in a choice of 6, 12 or 32 v, from conventional 110/120-v a-c power sources and are reported to be absolutely safe to use around metal structures, even in dripping wet conditions. Set consists of a step-down transformer housed in a moisture-tight case with 1 to 4 handlamp extensions that plug into receptacles on each end of carrying case. Supplied with 6-ft power extension with male-end plug that connects to conventional style grounded receptacles. Third wire in extensions connects ground to transformer case and to metal lamp guards. *Joy Manufacturing Company.*

Circle number (4) on reply card.

Portable Magnetic Tape Recorder

A portable magnetic tape recorder for geophysical seismic work, which features complete transistorization, light weight, and extreme portability, has been developed by the General Geophysical Company. The unit is known as the Geocord.



The field unit produces standard 24 channel magnetic seismic records despite its compactness and light weight. The complete recording system is contained in 2 cases, each weighing only 45 lb. The unit is hermetically sealed at every point. *General Geophysical Company.*

Circle number (5) on reply card.

Lubricator-Type Stuffing Box

Vernon Tool Company, Ltd., has announced the addition of a lubricator-type stuffing box to their line. The stuffing box is designed for wells that occasionally pump dry or need additional lubrication.

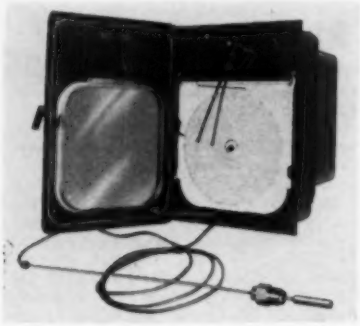
The cap of the box incorporates a chamber which is packed with absorbent wicking which is saturated with oil and lubricates the polished rod at all times. A wiper ring, built into the top of the cap, keeps the lubrication in and the dirt out. *Vernon Tool Company, Ltd.*

Circle number (6) on reply card.

New Equipment

BS&W and Temperature Recorder

A combination bs&w and temperature recorder for LACT units has been announced by Instruments, Inc. Assembly of both recording mechanisms in 1 case simplifies many pipeline installations where separate temperature and bs&w recorders would ordinarily be installed.



The temperature measuring system incorporated in the unit is a "filled system," with the bulb designed for location directly in the pipeline. Connection from the sensing bulb to the recorder is made using flexible stainless steel capillary tubing. Bs&w is recorded on 1 pen of the recorder with the temperature recorded on a second pen to provide simultaneous indication of both variables. *Instruments, Inc.*

Circle number (7) on reply card.

Chlorine-Free Paraffin Solvent

Developed in response to the oil industry's requests for a chlorine-free product, Visco 958 is a new paraffin solvent now being marketed by Visco Products. An oil soluble liquid, the solvent is used to remove paraffin deposits from producing wells, flow lines and storage tanks. Solvent action is made highly effective by the synergistic effect of semi-polar surfactants incorporated in the product. The manufacturer says Visco 958 will normally loosen and dissolve the most stubborn paraffin blocks with no need for any application of heat. Product is shipped in 55 gal steel drums. *Visco Products Company, Inc.*

Circle number (8) on reply card.

Light-Weight Plastic Core Tube

A new core tube, introduced by the Krayloy Plastic Pipe Company, is a real innovation for petroleum engineers. The "Cor-Tainer" is manufactured of high impact PVC plastic and conforms to standard dimension: 36 in. in length and 4.067 in. ID. For shipping, one end is permanently sealed while the other end is threaded to take a 4-in. cap.

The "Cor-Tainer" will not rust, rot or corrode under adverse conditions. It is air, oil and water tight and can be used repeatedly. Its shipping weight is only 7 lb. *Krayloy Plastic Pipe Company, Inc.*

Circle number (9) on reply card.

Repair Clamp and Coupling

A new all-around pipe repair clamp, the Dresser "360," made of stainless steel and Grade A malleable iron, provides an easy-to-install method of repairing full breaks or holes in asbestos-cement and cast iron lines. The manufacturer cites easy installation — simply remove the bolts from 1 side of the clamp, spring the clamp around the pipe, insert the bolts and tighten the nuts.

Besides being a clamp, the "360" is reported to be an excellent coupling. Asbestos-cement pipe with broken ends can be used by evening the ends of the pipe and joining. *Dresser Manufacturing Division.*

Circle number (10) on reply card.

Light-Weight Desander

Grant Oil Tool Company recently unveiled its new Spiro-Jet Desander which weighs only 56 lb, operates effectively under wide variations in pump pressures, maintaining clay and oil base muds in sand-free conditions under all normal drilling operations. Heart of the desander is a 1-piece liner of special oil and abrasive-resistant rubber which is quickly replaced as a unit when worn.

The desander is easy to install wherever the operator desires. It can be mounted in the mud system as an individual unit, or manifold-mounted with simple piping arrangements to provide desanding under all volumes and pressures. *Grant Oil Tool Company.*

Circle number (11) on reply card.

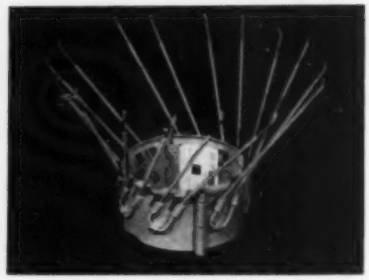
Extremely Hard Plunger Surface

A new plunger surface which is almost as hard as a diamond, resists abrasion and will not gall, is the newest development in subsurface pump plungers by Axelson Manufacturing.

The plunger is hard-faced with a nickel-chromium-boron material that is sprayed while in a molten state onto a mild steel tube. The hard-facing material is then fused at 1900 to 2000 F to form a molecular bond with the base metal. The surface is composed of extremely hard carbide and boride particles, held together in a nickel binder. The material is highly resistant to corrosion and provides maximum resistance to galling. *Axelson Manufacturing Company.*

Circle number (12) on reply card.

Spring-Loaded Scratchers



A new line of scratchers is announced by Byron Jackson Tools, Inc. The BJ Red Top scratcher features special coil spring steel fingers enclosing wire scratching elements. Each of the scratching fingers consists of a sheaf of 10 steel wires held fast in the tightly coiled spring. Protruding wires do the actual scratching and the coils spring them back to their original position after each stroke and prevent damage to the scratching fingers before and during insertion into the hole. Scratchers are manufactured in sizes to fit all API casing from 4½-in. to 13⅜-in. *Byron Jackson Tools, Inc.*

Circle number (13) on reply card.

Ultra-High Strength Steel

From U. S. Steel laboratories comes a new steel, dubbed the U.S.S. 12-MoV, which one day may have petroleum industry application. This new steel which requires minimum amounts of scarce alloys has a tensile strength of more than 225,000 psi up to 800 F. The steel was developed as an outer skin for missiles which must withstand high temperatures on re-entering the atmosphere after a trip into space. *U. S. Steel Corporation.*

Circle number (14) on reply card.

Plastic Pipe with Steel Jacket

A new type of pipe combining the strength of steel with the chemical resistance of plastic is being produced by Jones & Laughlin. The product, named "Jal-Jacket," consists of a rigid polyvinyl chloride tube which is jacketed with an electric resistance welded steel pipe.

It can be used to carry highly corrosive salt water used for water injection in secondary recovery systems and where sour crudes cause short service life for unprotected pipe. Actual field experience has indicated that the smooth inside surface of Jal-Jacket materially reduces the problem of paraffin build-up and scale depositions. *Jones & Laughlin Steel Corporation.*

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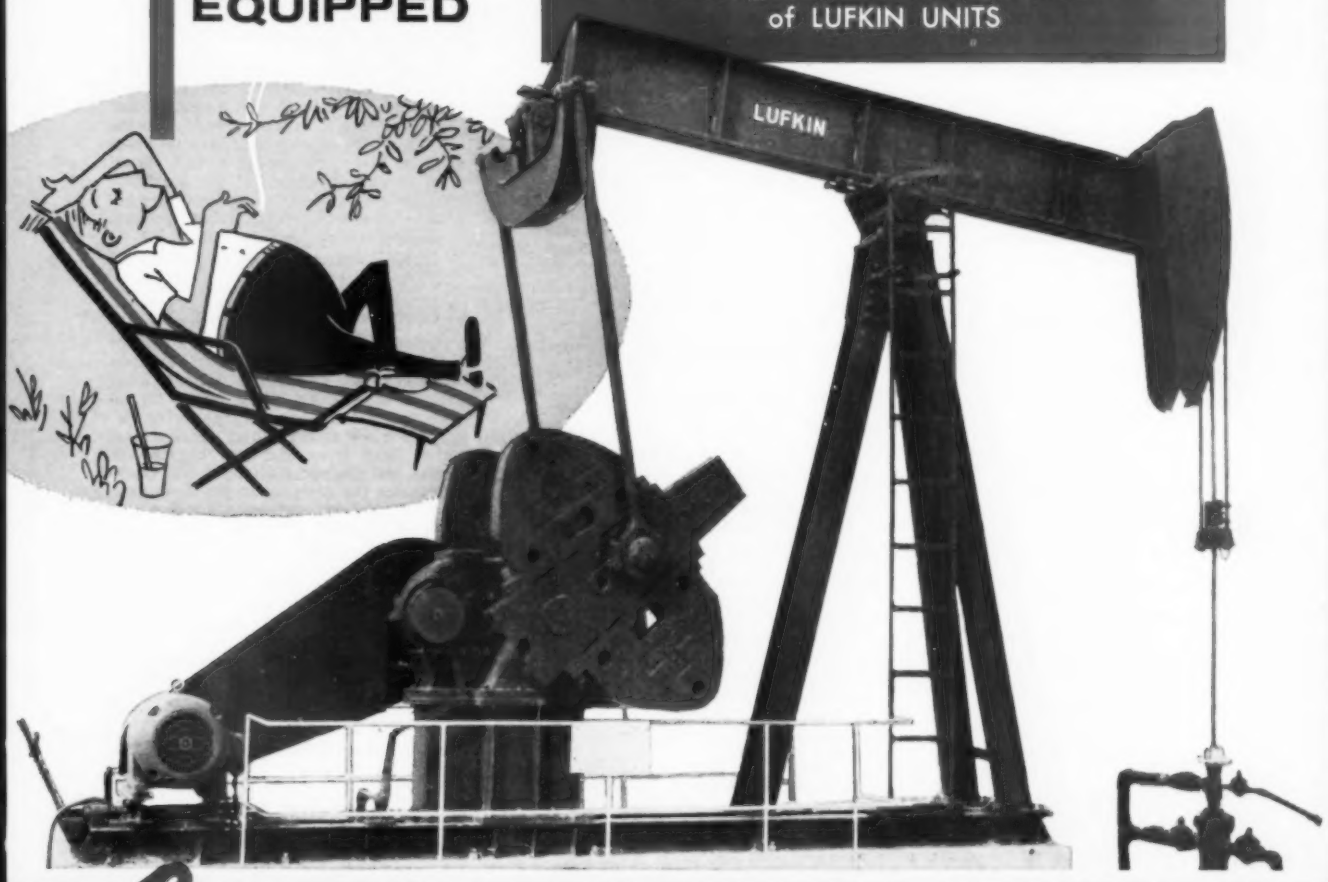

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Drilling-Producing Literature

Synchronous Generators for Diesels

New 10-insert loose-leaf bulletin features synchronous generators from 30 to 300 kw at 1800 rpm for use with diesel engines. All are compactly designed for minimum space requirements. Separate insert pages show generator and wall mounted control cabinets; connection diagrams for selecting voltages from 120 v to 480 v; generator and control interconnections; package control model chart; and insert of 340 service stations servicing Marathon motors and generators. *Marathon Electric Manufacturing Corporation.*

Circle number (16) on reply card.

Breakdown Acid Report

A report from Dowell Incorporated covers the application and results of Breakdown Acid, designed for breaking down formations ahead of fracturing, cementing and conventional acidizing operations. The booklet includes a description of the treatment, its uses, and laboratory data including surface tension, penetration through mud-contaminated packed-sand columns, and emulsion-forming tendencies of the treatment. *Dowell Incorporated.*

Circle number (17) on reply card.

Armored Cable Bulletin

A new 12-page illustrated bulletin, "Interlocked Armored Cables", is available from Rome Cable Corporation. The bulletin describes 4 types of interlocked cables —600-v, 5000-v, 15,000-v grounded neutral and 15,000-v ungrounded neutral. General information is given on installation, circuit flexibility, accessibility, moisture resistance, mechanical toughness, ampacity, and space requirements.

Four tables — 1 for each of the cables — give size, number of strands, insulation thickness, diameter, net weight, and the current ampere ratings. *Rome Cable Corporation.*

Circle number (18) on reply card.

Insert Pump Bulletin

The Fluid Packed Pump Company announces a new 4-page illustrated bulletin on the Oilmaster insert pump anchor. Technical bulletin covers installation and operational details of the pump anchor with the unique vertical-setting mechanism. *Fluid Packed Pump Company.*

Circle number (19) on reply card.

Explosion-Proof Housings

The Adalet Manufacturing Company has combined into a 16-page bulletin selection and specification data for their extensive line of cast-aluminum weatherproof and explosion-proof housings. For each housing listed, all photographic, dimensional and written data are gathered together in one spot. A full complement of explosion-proof sealing fittings is also shown for the more important needs. *Adalet Manufacturing Company.*

Circle number (20) on reply card.

Kobe Triplex Pump Bulletin

A 12-page illustrated bulletin on Kobe Triplex pumps has been issued by the manufacturer. Applications of the pumps include operation of hydraulic test equipment, lubricating systems, oilwell pumping and others. Complete description of the pumps and their ratings are contained in the bulletin. *Kobe, Inc.*

Circle number (21) on reply card.

Electric Log Catalog

Publication of the 1958 edition of Panhandle Electrical Log Service catalog has been announced. This book contains a complete compilation of all electrical and radioactivity logs released to the oil industry to October 29, 1957, by counties, by fields and by wildcat and development wells covering the Panhandle of Texas and Oklahoma and the adjoining areas in Colorado and New Mexico. *Panhandle Electrical Log Service.*

Circle number (22) on reply card.

Sump and Process Pumps

A bulletin describing its line of heavy duty vertical centrifugal sump and process pumps has been issued by Goulds Pumps. Single and duplex unit as well as wet and dry pit types are covered. Units are available for pit depths up to 20 ft with capacities to 1080 gal per min and heads to 290 ft. Bulletin includes specifications, sectional views, performance ratings, and a chart of materials of construction for interchangeability. *Goulds Pumps, Inc.*

Circle number (23) on reply card.

Twin-Lobe Rotary Pump Bulletin

Bulletin TLP-57 presents the features and operating characteristics of the recently developed Gaulin Twin-Lobe pump. Special emphasis is placed on a cosine rotor development called the Twin-Lobe design. It is said to have unusual simplicity and efficiency of operation, and is described and illustrated in detail.

The bulletin provides an analysis of performance characteristics, graphs on operating speeds and ranges, corrosion resistance charts, data on seals, and specifications for determining pump size, speed and horsepower. *Manton-Gaulin Manufacturing Company, Inc.*

Circle number (24) on reply card.

Replacing Shrink Thread Tool Joints

How to replace Spang double seal shrink thread tool joints is the subject of a new pocket-sized, 12-page booklet offered by National Supply Company. Two illustrated methods of removing worn or damaged tool joints, the preparation procedure and equipment, and the equipment and method for replacement of joints are outlined briefly and clearly. *National Supply Company.*

Circle number (25) on reply card.

Threaded Fittings Sealing Compound

Armite Laboratories offers a folder introducing their anti-seize sealing compound for threaded fittings, known as Led-Plate No. 250. The compound prevents seizure of galling of joints of stainless steel, aluminum, titanium, plastic or any metal-to-metal fit, and consists of 70 percent pure metallic lead suspended in a non-volatile hydrocarbon vehicle free from any additions of fillers, drying agents or other foreign materials. *Armite Laboratories.*

Circle number (26) on reply card.

Oil Well Heater Bulletin

A new booklet entitled "Corox Oil Well Heaters" is available from Westinghouse. The 4-page booklet describes the Corox electric oil well heater used to increase production of heavy crudes and high paraffin content oils. Included are such topics as advantages, construction, application, installation, operation, and selection of the heaters. *Westinghouse Electric Corporation.*

Circle number (27) on reply card.

Hard-Surfaced Pump Plungers

Hard-surfaced pump plungers and aluminum-bronze replacement parts are illustrated and described in a new 2-color folder showing the special design, coating and uses. These plungers have a hard-surfaced body attained through a spray-weld process invented by the manufacturer. In field tests, the plungers have reduced maintenance costs up to 40 percent. *H. L. Dacus Company.*

Circle number (28) on reply card.

V-Belt Drive Cost Bulletin

A booklet issued by the Gates Rubber Company assists in an economic analysis of many of the problems a designer must solve in developing V-belt drives for oil field operations. Approaching drive design from the standpoint of service level rather than from standard horsepower ratings, the method outlined in the booklet enables the designer to pin down specific annual costs and get a better evaluation of optimum drive design.

Belt replacement and lost production costs may be included as essential parts of pumping unit economics. Engineering data for the design of a drive are contained in a separate design bulletin. *The Gates Rubber Company.*

Circle number (29) on reply card.

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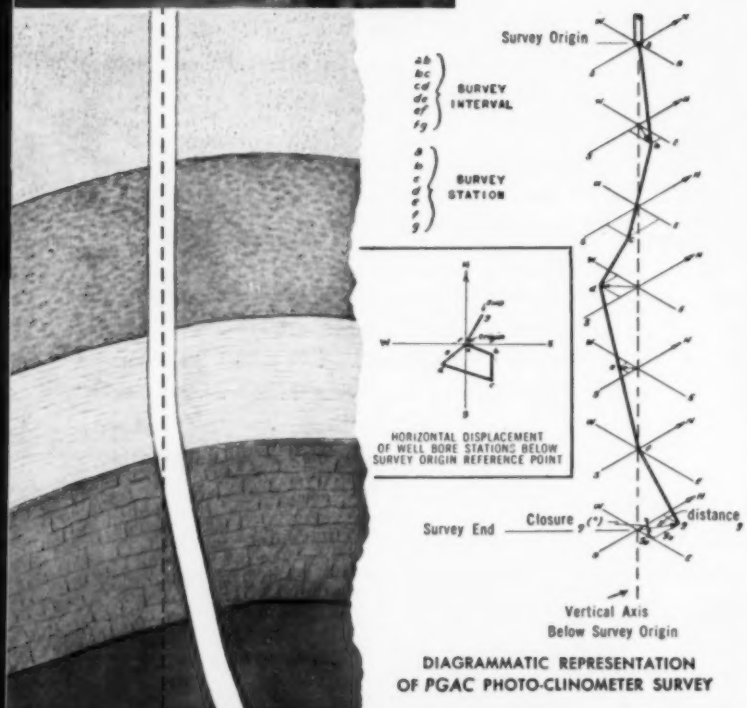

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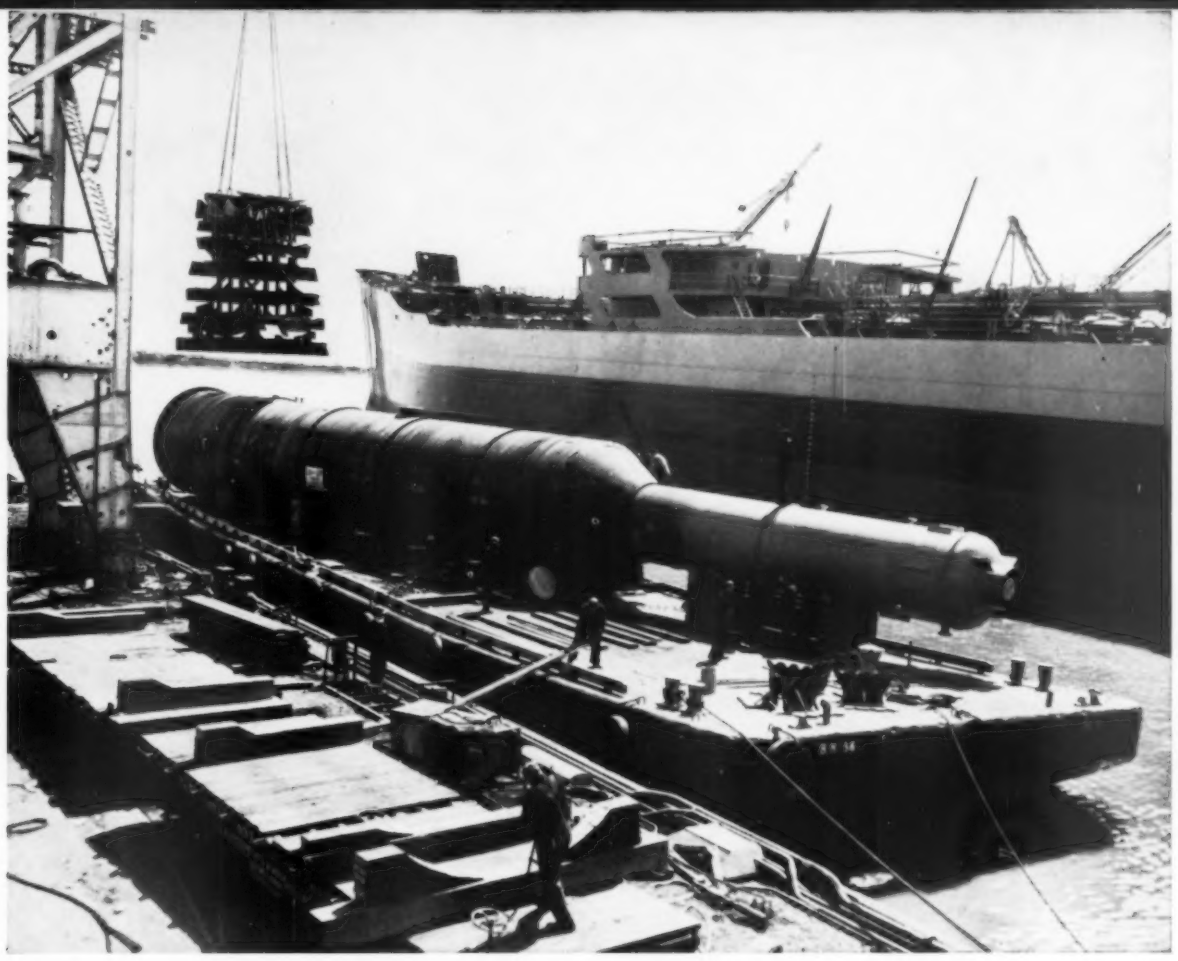

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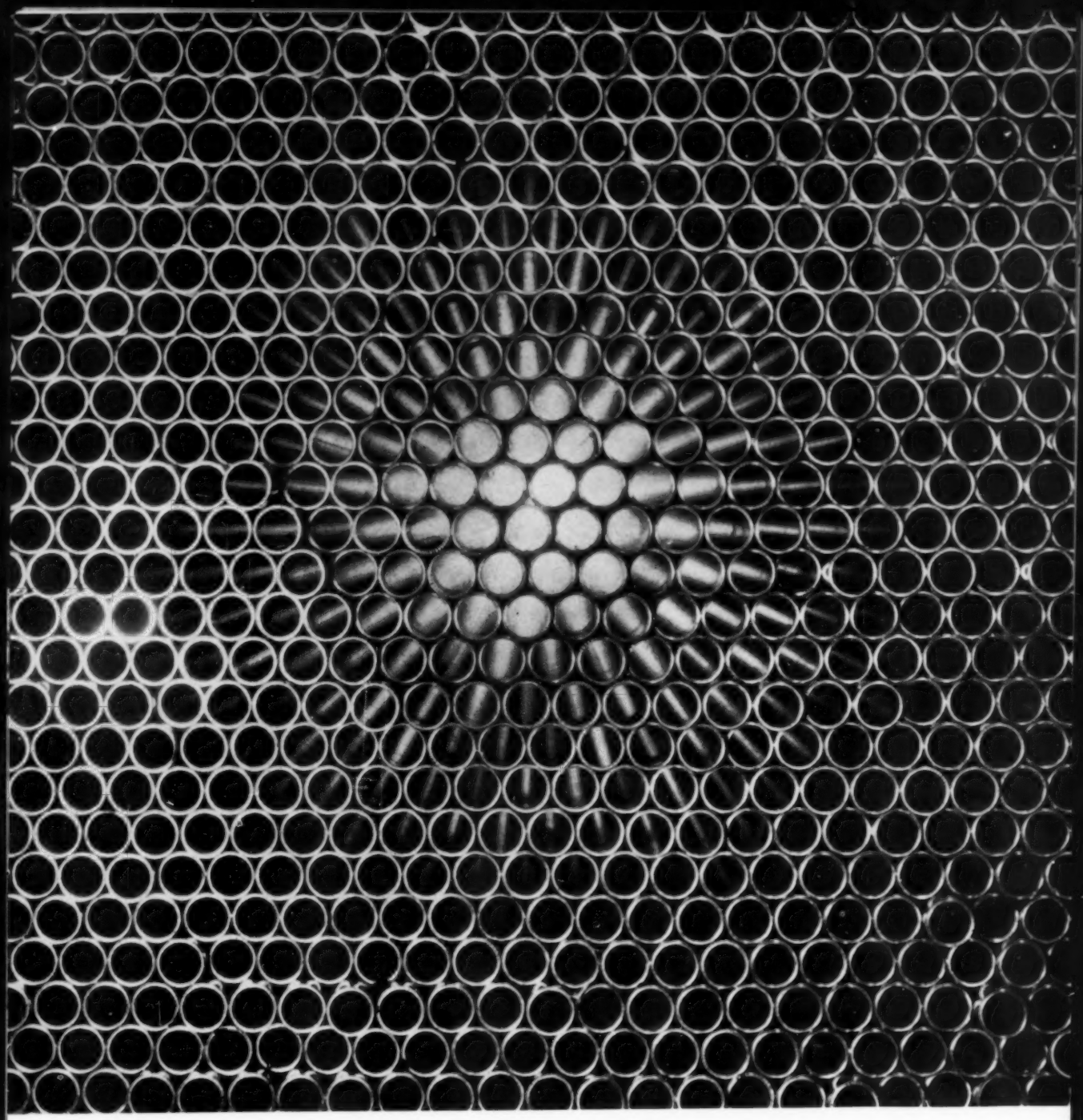

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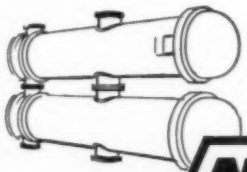

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New Projects in refining gas processing petrochemicals

St. Bernard Parish, Louisiana, will be the site of a new 150 MMcf per day gasoline plant to be built and jointly owned by Texas Natural Gasoline Corporation and Tennessee Gas Transmission Company. Contract has been awarded to Fluor Corporation with construction to begin in March 1958. With absorption refrigeration facilities operating at −20 F, fractionation units have been designed to handle 380,000 gal of liquid products per day. Completion of the project is expected in November 1958.

Compania Shell de Venezuela plans to build the first automatically controlled gas turbine power station in Venezuela. Westinghouse will build the 10,000 kw turbine station to power a new $85 million storage and loading facility on Lake Maracaibo. Cost of the station is in excess of $3 million and will enable Shell to handle 700,000 bbl per day.

Standard Oil Company (Ohio) will have a $1.25 million carbon monoxide fired boiler in their new Toledo, Ohio, refinery. Capable of handling the normal needs of a refinery, the boiler will produce 450,000 lb steam hourly. Babcock & Wilcox Company will build the boiler to operate by burning cat cracker flue gases.

Shell Development Company has begun construction of a new half-million dollar process development laboratory at Emeryville, California. To be three stores high and covering some 10,000 sq ft of ground, laboratory will be used for developing new petroleum products and petrochemicals.

Sinclair Chemicals, Inc. will begin construction of a new plant for the manufacture of paraxylene at Houston, Texas. New facility will produce in excess of 50 million lb per year and will be integrated into the refining units of Sinclair Refining Company at Houston. Unit will also produce about 60 million gal per year of pure toluene and mixed xylenes for sale to the chemical industry and use in gasolines.

The first Udex unit in England is now under construction at the Stanlow, England, refinery of Shell Refining & Marketing Company, Ltd. With a feedstock from an existing Platforming unit, the plant will produce an aviation gasoline blending component.

Petro-Tex Chemical Corporation has begun construction of a 3000 bbl per day sulfuric acid alkylation plant at Houston, Texas. Alkylate production will be bought by Plymouth Oil Company of Pittsburgh, Pennsylvania, with part of the feed stock supplied by Plymouth. Production will be made from butylenes and will be aviation gasoline quality.

British Hydrocarbon Chemicals, Ltd. has awarded contract to Scientific Design Company, Inc., to design a cumene manufacturing plant at Grangemouth, Scotland. Scheduled to go onstream in mid-1959, production from this unit will be used in the manufacture of phenol at the same location.

Farbwerke Hoechst AG has announced plans to build a gasoline cracker for ethylene production at their Anagorna works at Gendorf in Bavaria. Unit may also be run with crude oil at a later date. Company also has under consideration a plan for a unit to recover chlorination products from a nearby natural gas field.

Clark Oil & Refining Company has started construction on a 12,500 bbl per day cat cracking unit at their Blue Island, Illinois, refinery. Procon Incorporated has the construction contract with license by UOP.

Shell Chemical Company will build two multi-million dollar petrochemical plants at Norco, Louisiana, states R. C. McCurdy, company president. Scheduled to begin in early 1958, one plant will make acrolein and the other plant will convert a portion of the acrolein to glycerine at an original rate of 35 million lb per year.

Magnolia Petroleum Company is building a new crude oil distillation unit at their Beaumont, Texas, refinery. The tower, with a 23-ft diameter, will process 100,000 bbl per day and rise 166 ft into the air. Unit is scheduled for completion in early fall and will eventually replace several smaller crude units there.

A new synthetic rubber plant will be built in Europe and will go onstream by mid-1959. B. F. Goodrich Chemical Company and Algemene Kunstzijde Unie N. V. have formed a new company to produce the product. Plant will produce butadiene-styrene latex, nitrile latex, and high-styrene polymers. Location of the unit will be Arnhem, Holland.

Humble Oil & Refining Company has started expansion of its paraxylene unit at the Baytown, Texas, refinery. Scheduled for completion in mid-1958, the unit will then have a capacity of about 66,000,000 lb per year. Company officials say the expansion will give the unit the largest capacity in the nation.

Steelman Gas, Ltd. has begun construction of a new $20 million natural gasoline plant in southeastern Saskatchewan, Canada. Plant will produce butane, propane and sulfur in addition to natural gasoline. Designed to process 25 MMcf per day, dry gas will be sold to Saskatchewan Power Corporation.

British American Oil Company, Ltd. has announced plans to build a new catalytic reformer at their Moose Jaw, Saskatchewan, refinery. Cost of the unit will be approximately $4 million with a design capacity of 5400 bbl per day.

A natural gasoline plant in the Blocker field, south of Marshall, Texas, is now under construction. Pan American Petroleum Corporation and La Gloria Oil & Gas Corporation have joined hands in building the plant in the Slade gas unit. Plant is expected to be completed by late 1958.

The Texas Company has joined a group of other oil companies to build a natural gasoline plant in Beaver County, Oklahoma, with Texaco as the operator. Gas from the Camrick and Grand Valley fields will be transported by Natural Gas Pipeline Company of America to plant site with the feed for the plant taken from the NGP main line. Estimated cost of the project is $1.5 million.

Ohio Oil Company has announced plans for an addition to its research laboratory at Littleton, Colorado. A total of 70,000 sq ft of space will be added as two new wings to be used for special research work.

Stauffer Chemical Company will build a new hydrofluoric acid plant at Louisville, Kentucky. New plant will be adjacent to Stauffer's petrochemical plant. All design and engineering is being done by the company.

Transcontinental Gas Pipeline Corporation has a $2 million gas treating unit now under construction. Located in McMullen County, Texas, unit will remove acid and water from gas in the TGP lines. Fluor Corporation is the contractor.

A new butadiene-styrene plant will soon go up near Pernis, Holland. Royal Dutch Shell's operating company, Bataafsche Petroleum Maatschappij, has announced plans for building this 50,000 ton per year plant.

Methods for making a new antiknock compound are investigated by an Ethyl research chemist.

How Ethyl Chemical Research Advances Antiknock Technology

Break-throughs in Organo-Metallic Chemistry Point to More Effective Antiknock Agents and New Tetraethyllead Production Methods

EVER SINCE the discovery of tetraethyllead as the first practical antiknock additive, Ethyl scientists have been searching for even more effective and economical antiknock agents.

Extensive research on both organic and metal-organic materials in our Detroit Research Laboratories has shown that the metals are the most promising. Our research also has shown that these materials promise important new advances in tetraethyllead production methods.

Our efforts to learn more about organo-metallic compounds also have enabled us to make significant contributions to chemical knowledge outside the antiknock field. Ethyl's continuing publication of such information contributes to the expansion of knowledge in this field of chemistry.

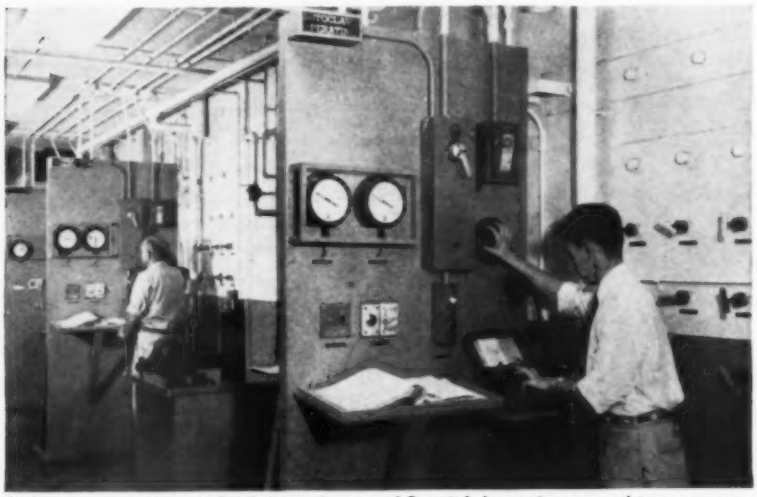
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Developments in Organo-Metallic Chemistry Offer Antiknock Promise

Much of the early work on metallic antiknocks was hindered by the lack of compounds with solubility, volatility, and stability characteristics suitable for use in gasoline.

Recent chemical break-throughs, used to good advantage by Ethyl scientists, have indicated that many metals might be incorporated in organic compounds. The synthesis of organo-metallic compounds with suitable physical characteristics has enabled us to consider a number of them as antiknock possibilities.

One organic manganese compound, which we call AK-33X, has shown promise as an aviation fuel constituent to increase the power of piston aircraft engines. It is now undergoing extensive testing in both aircraft and automotive engines. Many oil companies are thoroughly examining AK-33X to determine its effectiveness as an antiknock and as a supplement to tetraethyllead in their different motor gasolines and constituents.



High-pressure autoclaves in Ethyl's Baton Rouge and Detroit Laboratories are used to run organo-metallic reactions at high pressures and temperatures.

Tetraethyllead Is Synthesized From Common Lead Compounds

Another recent accomplishment of Ethyl's organo-metallic research is a new method of synthesizing tetraethyllead from a wide range of organo-metallic compounds by reacting them with common lead compounds such as lead oxide, lead sulfide, and lead dioxide. This radical departure from present technology circumvents the use of sodium and chlorine.

Major development work remains to be done before this new method can be used commercially. However, our studies of all phases so far have led us to believe that considerable advances in tetraethyllead production methods are within reach.

Chemical Contributions Outside Antiknock Field

An added benefit of the synthesis of tetraethyllead and other organo-metallic compounds is the development in our laboratory of improved techniques for manufacturing triethyl aluminum. This compound is of high interest as a possible new route to the manufacture of tetraethyllead.

Triethyl aluminum also is important as an ingredient in catalysts for olefinic polymers and particularly high density polyethylene, as an alkylation agent for active metals and less active salts, and as a reducing agent comparable to lithium aluminum hydride. Triethyl aluminum and trimethyl aluminum also are being considered for military fuel applications.

The Ethyl scientific team has a solid research background in fuel-engine relationships plus a comprehensive knowledge of organo-metallic chemistry.

In addition, the Research Laboratories are uniquely organized to evaluate the potential engine applications of new fuel or lubricant additives. These are good reasons why we look forward to even more important advancements in the fields of antiknock chemistry and organo-metallic research.

In so far as possible, data on all Ethyl's current research projects in antiknock technology and organo-metallic research will be made available to the Oil Industry.

How Ethyl Research is helping you

In the 36 years since the discovery of tetraethyllead as the first practical antiknock additive, Ethyl's search for new antiknock agents has continued.

New compounds and their value to the Petroleum and Chemical industries are investigated on a continuing basis in our laboratories in Detroit, Mich. and Baton Rouge, La.

Research in the field of organo-metallic chemistry is only one of the many facets of Ethyl's research program.

Ethyl's scientific manpower, experience and facilities are dedicated to the search for fundamental knowledge of the behavior of fuels and engines, guided by the needs of the Petroleum Industry.

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BRIGHT NEW HORIZONS FOR ASPHALT

• DEMAND

H. O. JASON

Asphalt demand is scheduled to reach 137 million bbl annually according to Herbert O. Jason's forecast. Mr. Jason is executive vice president of Boni, Watkins, Jason & Co., Inc., consulting firm with offices in New York and Washington. He is also president of Diversification, Institute, Inc., a subsidiary of BWJ. Since receiving his MME in Europe in 1937, Mr. Jason has been engaged in administrative and consulting capacities in both American and foreign industry.

• PRODUCTS AND SPECIFICATIONS

A. J. HOIBERG

S. H. ALEXANDER

Recent progress in asphalt uses and specifications is discussed by Dr. Arnold J. Hoiberg and Stephen H. Alexander. Dr. Hoiberg, who received his PhD from University of Wisconsin, is assistant research director for Flintkote Company's Whippany, New Jersey, laboratories. Prior to assuming his present post in June 1957, he was in charge of asphalt research and technical service for Lion Oil Company (a division of Monsanto Chemical Company) at El Dorado, Arkansas. Steve Alexander is a senior research chemical engineer in Lion Oil's asphalt research and development group at El Dorado. His activities have been centered around asphalt ever since he joined Lion Oil in 1948. He holds a BS degree in chemical engineering from the University of Oklahoma; following graduation in 1948 he spent a year in the Navy and two years with Phillips Petroleum Company.

• ADDITIVES

What's ahead for additives is briefly discussed by Warren B. Warden, owner-manager of Miller-Warden Associates, consulting firm with principal offices in Swarthmore, Pennsylvania. Mr. Warden has been associated with various phases of the asphalt industry since graduation from the University of Michigan in 1935. He has a bachelor of science degree in chemical engineering.

W. B. WARDEN

• PLANT DESIGN

Modern asphalt plants — manufacture, storage, blending, and shipping — are fully described by Phillips Petroleum Company asphalt products engineer D. W. Gagle. Mr. Gagle has been active in the asphalt industry since 1950 when he was transferred to Phillips' Bartlesville, Oklahoma, headquarters. He started in the oil industry in 1938 with Home Oil and Refining Company, was chief chemist with Home Oil in 1948 when Phillips acquired the properties of the company.

D. W. GAGLE

• "SYNTHETIC" ASPHALTS

Solvent extraction processes are showing the way to tailor-made asphalts, claims asphalt technologist E. J. Barth in his article under the same title. Mr. Barth makes New York City his headquarters. He holds several patents in the field of asphalt technology and has written several articles including "Asphalt — Prime Road Building Material," appearing in the April 1958 issue of *The Refining Engineer*.

E. J. BARTH

ASPHALT DEMAND

137 MILLION BARRELS IN 1960-67?

Herbert O. Jason
Executive Vice President, Boni, Watkins, Jason & Co.

DESPITE RELAXED DEMAND for asphalts in the year gone by, outlook for sales appears to be cheerful — to the extent of about 137-million bbl annually during 1960-67. As Fig. 1 shows, most of the push will come from paving asphalts, scheduled to rise from about 67-million bbl in 1956 to a total of about 106-million bbl in 1960-67—an increase of a little more than 58 percent! The only cloud on the horizon is the possible effects and extent of the current business dip.

Here is an analysis of the asphalt market, past, present, and future. End use patterns, production and demand profiles, and geographical patterns are all considered. These are interesting patterns, pointing up the strengths and weaknesses of the resurgent asphalt industry.

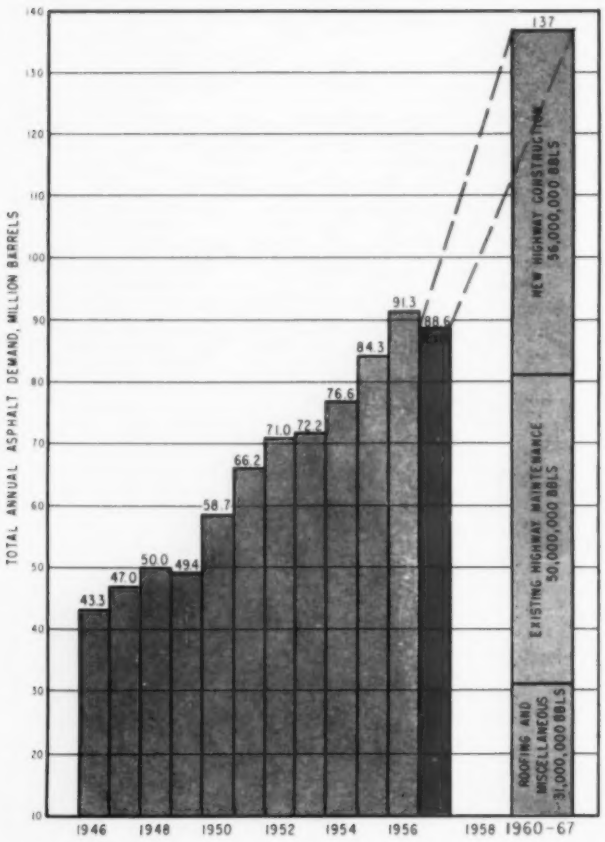

FIG. 1. Total annual asphalt demand in USA, past, present, and future. Sources: 1946-1956 from Table 2; 1957-67-estimated.

End-Use Pattern

Analysis of the market outlook for asphalt must be based on a study of the current end-use pattern of asphaltic products. As Table 1 indicates some 70 percent of the roughly 95 million bbl of petroleum asphalt sold in the United States in 1956 was accounted for by paving products. Sales for roofing products amounted to about 20 percent, and for all other purposes to some 10 percent of the total. The trend at present is for asphalt used for paving to represent a greater proportion of the total market, with the proportion used for roofing purposes constituting a diminishing share of the total market.

Bearing out this stated trend, Table 1 indicates that sales of asphalt used for paving increased 13.39 percent between 1955 and 1956, while sales for roofing uses declined 2.61 percent and for "other uses" increased 16.09 percent, in the same period.

Production and Demand

These percentages, of course, represent shares of a market which has been growing, and growing at a generally accelerating rate. Table 2 indicates that production and demand have not only risen sharply in the period since World War II, but have risen in more recent years at an increasing rate. In the last two years for which data are available, the percentage rate of increase in production averaged 10 percent, as compared with an average increase of 3.2 percent in 1953-1954. For demand, these increases were 3.9 and 9.2 percent, respectively, in 1953-1954 and 1955-1956.

Referring to Table 2, it will be noted that occasionally there are rather sizable differences in the figures for production and demand. Principal factors accounting for those differences are changes in the level of stocks and in the relationship of exports and imports.

However, imports and exports make up a very small part of the total asphalt market picture. In 1956, 3.6 million bbl of asphalt were imported and 1.5 million bbl exported, or about 4 percent and 1.7 percent, respectively, of domestic production. Over the past 10 years there has been a gradual upward trend in the volume of imports, while exports have fluctuated rather widely and exhibited no pronounced trend, up or down.

"three fifths of sales are made in 15 states"

Geographical Patterns

The geographical distribution of domestic production of asphalt traces a pattern of concentration in four main sections of the country, as can be seen in Table 3. Of the total 1956 production (slightly less than 91 million bbl), the East Coast states accounted for 22.43 percent, the region roughly identifiable as the Midwest for 22.12 percent and the Pacific Coast and the Mountain states for 20.67 percent. The remaining 34.78 percent, or slightly more than one-third, came from the Southwestern region in which a large proportion of the domestic oil production and refining facilities is concentrated.

TABLE 1. Total Annual Sales of Petroleum Asphalt in the United States According to Use.
— 1955 and 1956 —

	Sales in thousand bbl		Percent change
	1955	1956	
Paving products			
Asphalt cements	32,268	38,553	
Cutback asphalts	22,212	23,658	
Emulsified asphalts	4,735	4,932	
Total	59,214	67,143	13.39%
Roofing products			
Asphalt cements and fluxes	19,197	18,669	
Emulsified asphalts	66	91	
Total	19,263	18,759	−2.62%
All other products			
Asphalt cements and fluxes	7,515	8,767	
Emulsified asphalts	249	246	
Total	7,764	9,013	16.09%
Total asphalt products	86,241	94,916	10.06%
	Percent of total sales		
	1955	1956	
Paving products	68.66%	70.74%	
Roofing products	22.34	19.76	
All other products	9.00	9.50	
Total	100.00%	100.00%	

Note: Figures may not add to total indicated due to rounding.
Source: United States Bureau of Mines, Mineral Industry Surveys, "Sales of Asphalt in 1956," pp.4-7.

TABLE 2. United States Production and Demand for Asphalt.
— 1946-1956 —

	Production		Demand	
Year	Thousand bbl	Year-to-Year % change	Thousand bbl	Year-to-Year % change
1946	44,911	—%	43,253	—%
1947	49,286	9.74	47,023	8.72
1948	51,919	5.34	49,962	6.25
1949	49,007	− 5.61	49,362	− 1.20
1950	58,240	18.84	58,677	18.87
1951	66,302	13.84	66,179	12.79
1952	70,312	6.05	71,007	7.30
1953	72,409	2.98	72,208	1.69
1954	74,912	3.46	76,577	6.05
1955	83,121	10.96	84,286	10.07
1956	90,636	9.04	91,347	8.38
1957 (est.)	—	—	88,600	− 3.00
1946–1956 percentage change		101.81%		111.19%

Source: "Petroleum Facts and Figures," 9th and 12th Editions.
United States Bureau of Mines, Mineral Industry Survey, "Crude Petroleum and Petroleum Products," 1956 (Final Summary), Annual Petroleum Statement No. 422.

Outlook for Capacity

One source reports that as of January 1, 1957, domestic refineries had an asphalt production capacity of about 136-million bbl annually. A survey just completed by the editors of *The Refining Engineer* reports total capacity on January 1, 1958, is approximately 150-million bbl per year.*

Even with a peak anticipated demand for 137-million bbl annually by 1967 there appears to be little, if any, need for expanded facilities. Asphalts imported from Caribbean area refineries add significantly to our supply and further, greater asphalt throughput is possible in this country by altering operations to make asphalts rather than residual fuels from certain crudes.

Distribution of Capacity

Data on productive capacity of asphalt plants and their aggregate sales, by states, as compiled in Table 4, indicate that in 1956 three-quarters of the productive capacity and more than three-fifths of the sales were concentrated in the 15 states there listed. Further examination of the table reveals that more than 40 percent of domestic production of asphalt in 1956 came from seven states. Ranked in the order of their respective contributions to the total output, these states were: California, Illinois, Texas, Ohio, Pennsylvania, New York, and New Jersey.

The usual pattern of distribution of asphaltic product sales have been such that the greater portion finds a market close to the source of production. Relatively high transportation costs and relatively low unit value of the product account for this situation.

Asphalt and Highways

The federal program. With sales of asphalt for paving purposes constituting 70 percent of total sales, it is obvious that the future market outlook for asphalt demand is highly correlated with the level of highway construction. Consequently, the superhighway construction program authorized by Congress in mid-1956 will exert an upward pressure on asphalt demand. An appropriation of $27 billion was provided to cover the federal government's 90 percent share of the estimated total cost of the projected 41,000-mile interstate network. Con-

* Full results of this survey will be available in a paper "Correlating Asphalt Production and Sales" to be presented by the editors at the Western Petroleum Refiners Association Annual Meeting at San Antonio, Texas, March 24.

"asphalt means better, cheaper highways"

struction expenditures were to be spread over a 13-year period.

Only about 1330 miles have been completed so far, but the program is moving forward more rapidly now that spring is approaching. This means that to a small extent in 1958, and to an increasing extent thereafter, refiners can expect to see a rise in asphalt demand to meet the needs of this major construction program.

Since the super-highway act was passed it has been amended, raising the federal ante to $44 billion, extending the 13-year construction period (1957-1969) to 20 years, and authorizing the Bureau of Roads to add 7000 miles of new routes to the network originally planned.

Advantages for asphalt highways. That asphalt will share to a major extent in the road-building boom seems beyond question. According to the Asphalt Institute, of the total 920,000 miles of surfaced highways in this country, an estimated 800,000 miles are paved or covered with asphalt. Its use for this purpose in recent years has continually increased, while that of its chief rival — Portland cement — has been declining.

Main reasons advanced for preferring asphalt to cement for paving are its proved durability, safety, comfort, and relatively low cost. Regarding this latter advantage, the Asphalt Institute has compared the initial costs of asphalt and cement toll road pavements. For such super-highways, exclusive of the outlay for right-of-way, but inclusive of that for toll gates and similar appurtenances, the average cost per mile runs between $500,000 and $1,000,000 for asphaltic concrete pavement, and to about $1,400,000 per mile for concrete pavement.

The famed New Jersey Turnpike offers a case in point. The lowest construction bid price for asphalt was over $5,000,000 lower than that for cement, permitting a saving of about $46,000 per mile of toll road. On the Massachusetts Turnpike, likewise asphalt-paved, the saving thereby achieved was estimated by the consulting engineers to amount to no less than $123,000 per mile. Moreover, indications are that maintenance costs are also lower for asphalt. An engineer-

TABLE 3. United States Production of Asphalt, by Districts. — 1956 —

	1956 Production	
	Thousand bbl	Percent of total
East Coast[1]	20,332	22.43%
Appalachian No. 1[2]	1,267	1.40
Appalachian No. 2[3]	1,837	2.03
Indiana, Illinois, Kentucky, Tennessee, Michigan, and part of Ohio	16,032	17.69
Minnesota, Wisconsin, North Dakota, and South Dakota	910	1.00
Oklahoma, Kansas, Missouri, Nebraska and Iowa	10,418	11.49
Texas Inland[4]	4,508	4.97
Texas Gulf Coast	5,907	6.52
Louisiana Gulf Coast[5]	5,316	5.87
Arkansas, Louisiana, and parts of Mississippi and Alabama	4,912	5.42
New Mexico	462	0.51
Rocky Mountain[6]	5,892	6.50
West Coast[7]	12,843	14.17
Total	90,636	100.00%

[1] Includes District of Columbia and the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, and parts of New York and Pennsylvania.
[2] Includes West Virginia and parts of New York and Pennsylvania not included in East Coast District.
[3] Includes part of the state of Ohio.
[4] Includes the state of Texas except the Texas Gulf Coast District.
[5] Includes parts of Louisiana, Mississippi, and Alabama.
[6] Includes Montana, Idaho, Wyoming, Utah, and Colorado.
[7] Includes Washington, Oregon, California, Nevada, and Arizona.
Source: United States Bureau of Mines, Mineral Industry Survey, "Crude Petroleum and Petroleum Products," 1956 (Final Summary), Annual Petroleum Statement No. 422.

TABLE 4. Sales of Asphalt in 1955 and 1956, and Asphalt Capacity as of January 1, 1957: 15 Leading States Compared with United States.

	Sales		Number of Plants Mfg. Asphalt[1]	Asphalt Capacity[1]	
	1955 (thousand bbls)	1956		Bbl per Stream Day	Bbl per Calendar Day (4) X 0.90[2]
	(1)	(2)	(3)	(4)	(5)
California	8,182	9,047	21	73,189	65,870
Texas	5,538	5,243	12	41,415	37,274
Florida	3,092	3,348	1	1,350	1,215
Illinois	5,360	6,340	8	21,507	19,356
Kansas	1,368	1,995	9	22,040	19,836
Missouri	2,415	2,589	1	3,800	3,420
New Jersey	4,587	4,245	4	24,400	21,960
New York	4,353	4,694	3	5,580	5,022
Pennsylvania	4,582	4,711	3	11,378	10,240
Ohio	4,554	5,067	4	22,800	20,520
Indiana	2,393	2,989	3	21,400	19,260
Massachusetts	2,082	2,574	1	10,000	9,000
Louisiana	2,159	2,503	5	18,065	16,258
Michigan	1,975	2,295	3	7,100	6,390
Maryland and District of Columbia	1,851	1,937	3	24,700	22,230
Total of 15 States	54,491	59,577	81	308,724	277,851
Total United States	86,241	94,916	127	412,736	371,462
15 States as Percent of Total United States	63.18%	62.77%	63.78%	74.80%	74.80%

[1] As of January 1, 1957.
[2] Figures converted from stream day data by using conversion factor of 90 percent (330 stream days ÷ 365 calendar days).
Source: Oil & Gas Journal, *Plant and Personnel Directory, 1957-1958*, pp. 2-16.
United States Bureau of Mines, Mineral Industry Survey, *Sales of Asphalt in 1956*, p. 7.

ing study covering highway maintenance costs in Pennsylvania during the 1950-1954 period found that average annual maintenance cost per mile of asphalt pavement was $223.99 compared with $494.96 for cement pavement.

Outlook for Asphalt Demand

Demand for asphalt is anticipated to remain at a high level, therefore, at least until 1976, and, because of maintenance requirements, for a long time thereafter.

Highway uses. More definite estimates of shorter term demand for this use are possible. The United States Bureau of Roads has estimated future asphalt requirements for *new* highway construction (including but not limited to the interstate super-highway requirements) at 56 million bbl a year from 1960 through 1967. Past experience indicates that the proportion of asphalt used for new construction and that used for maintenance and resurfacing are about equal. It is estimated, accordingly, that about 50 million bbl a year will be used for road maintenance during the peak years of interstate superhighway construction, *viz.*, 1960-1967.

Roofing and "other" uses. Estimates of demands for asphalt for other than paving purposes are somewhat more difficult, as reliable projections of expenditures on housing, etc., are not available. It has been estimated, nevertheless, that use of asphalt for roofing and other purposes is expected to reach 31 million bbl a year by 1962. Within the category of "other uses" (which includes waterproofing of walls, floors, etc., pipe coatings, molding compounds, blending with rubber, briquetting of coal and coke, and manufacturing of paints, enamels, and lacquers), the most promising market appears to be as a binding agent for railroad fill, ballast, and embankments, for irrigation ditches, and to retard beach erosion.

Effect of Overall Business Conditions

One must not ignore the very real possibility that the current business recession will get a good deal worse before it gets better. On the positive side, however, is the fact, evident from Table 2, that the 1949 and 1953 interruptions of the forward thrust of the economy did not significantly retard the expansion of demand for asphalt. Unfortunately, the impact of a setback of greater duration and severity than those of 1949 and 1953 cannot be determined with precision. Whether a countercyclical expansion of the road-building program would occur, and whether such an expansion would compensate for the decline in asphalt used for other than paving purposes, cannot be determined. ★ ★ ★

PROGRESS IN ASPHALT USES AND SPECIFICATIONS

Stephen H. Alexander,
Lion Oil Company,
A Division of Monsanto Chemical Company

Arnold J. Hoiberg,
The Flintkote Company

MORE THAN 70 PERCENT of the nation's asphalt production goes into the construction of highways. The roofing industry, with some 20 percent, is the second largest consumer. Additionally, use of this versatile material is growing rapidly for diverse products which include various protective coatings, membranes for seepage control in hydraulic structures, vapor barriers, joint compounds, adhesives, and chemicals.

History of Use

Asphalt has had a long history of use for highway construction. With the advent of the automobile it was first used as a dust palliative and then as a binder and waterproof agent in blade mixes with existing aggregates on sand or gravel roads.

Probably the utility of petroleum asphalts was first noted from spillages which occurred in the handling and hauling of crude oil, and initially there was little or no engineering basis for the selection of asphalt materials, or for that matter other aggregates and methods of construction.

Although by modern standards the performance of such roads was not outstanding, they provided all-weather roads and answered a definite need at very low cost. From such beginnings, as traffic has increased to the high traffic coverages of expressways, engi-

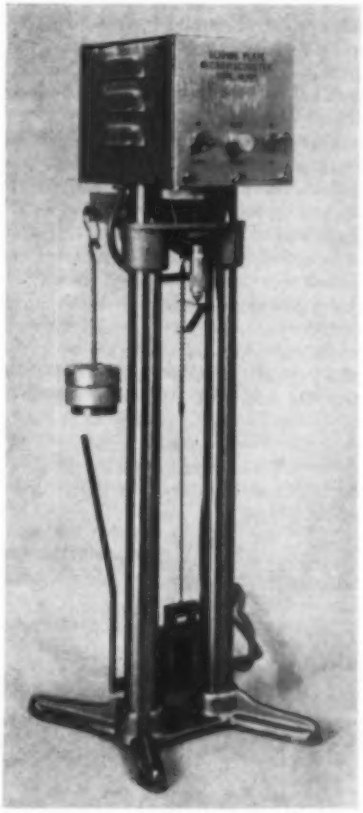

FIG. 1. This sliding plate viscosimeter is used to determine viscosity of very thin films of asphalts and other petroleum products.
— Courtesy Hallikainen Instruments

"more fundamental performance data are needed"

neering design and construction practice have improved and today over 85 percent of state pavement mileages are of the bituminous type. Present engineering specifications and methods have permitted construction of asphaltic concrete highways of high load carrying capacity with an unexcelled record of performance, safety, and upkeep.

Specifications for Road Asphalts

Initially, specifications for road construction asphalts were written individually by cities, counties, and states. These were usually based mostly upon requirements to identify particular materials rather than upon a performance basis. Producers could supply little performance information and were faced with supplying literally hundreds of grades of materials with a maze of different requirements.

Several organizations, with the most active being The Asphalt Institute, The American Association of State Highway Officials and the American Society for Testing Materials, have done much to reduce the number of grades of asphalt and standardize requirements, with all issuing specifications for purchase.

However, many purchasers, including states, cities, and counties still buy under individual specifications which require special products for compliance, and there still is much divergence of opinion as to basic properties required for optimum performance in the highway. Bituminous mixes have very complex properties under moving loads and asphalt itself is a very complex material from standpoints of both physical and chemical attributes, and never has lent itself readily to be interpreted by rational tests.

Specification requirements have remained for the most part based upon empirical tests, such as moisture, flash point, consistency tests as the penetration and ductility, solubility tests, ash contents and usually a loss on heating test with the material as a relatively thick layer in a container.

There long have been thoughts that such tests, while informative, do not relate to actual performance conditions. This awareness has increased greatly in recent years and there is now under way considerable exploration with some revision and introduction of new test requirements for paving asphalt. Within the Asphalt Institute group, there has been an effort to critically review all requirements to reduce and better standardize grades of paving materials, and to have more rational viscosity requirements. There has been considerable discussion of better control of the curing rates of the liquid products, but no ready solution has become apparent either in ASTM or committees of the Asphalt Institute.

Limitations in Present Specifications

One of the biggest shortcomings of current specifications for many asphalt uses has been that they do not include requirements for accurately predicting durability, and indeed some of the factors involved are just becoming known. Thus, in pavement uses, the asphalt functions as a very thin film upon aggregate and filler particles, being subjected as a thin film also to elevated temperatures during mixing. That action under thin film conditions is entirely different than under thick film conditions has been pointed out. It has also become known that relative durabilities in thin films at elevated and at ordinary temperatures can be very different.

As a more practical approach for measuring thin film conditions, the Bureau of Public Roads has developed a thin film oven test, which has been adopted by several states and other groups. The Cleveland open cup flash point has been changed to the closed type by several states to better measure smaller amounts of volatile vapors which might be present and prevent masking of such vapors by non-bituminous materials as silicones. There has been adoption of consistency requirements at elevated and at lower temperatures to better reflect mixing and use conditions.

TABLE 1. Specifications for Asphalt Cements. The Asphalt Institute

Characteristics	ASTM method	Industrial and Special	Paving			
Penetration, 77 F, 100 g, 5 sec.	D5	40–50	60–70	85–100	120–150	200–300
Flash point (Cleveland Open Cup), F.	D 92	450+	450+	450+	425+	350+
Loss on heating, 325 F, 5 hr, %	D 6	1—	1—	1—	2—	2—
Penetration after loss on heating 77 F, 100 g, 5 sec, % of original	D 5	70+	70+	70+	70+	60+
Ductility						
At 77 F, cms	D 113	100+	100+	100+	60+	—
At 60 F, cms	D 113	—	—	—	—	60+
Solubility in carbon tetrachloride, %	D 4*	99.5+	99.5+	99.5+	99.5+	99.5+
Temperature of use						
For spraying, F	—	275–350	275–350	275–350	275–350	275–350
For mixing, F	—	275–325	275–325	275–325	275–325	200–275

*Except that carbon tetrachloride is used instead of carbon disulfide as solvent, Method No. 1.

Fundamental Data Are Needed

While these test changes give improved information they also point out the fact that more fundamental data are needed as to the mechanism of and rate of change which properties of asphalt undergo in service. Thus, the prediction of rate of change of asphalt properties which might occur during mixing and placement and under pavement conditions would be most important but fundamental data are lacking as to the changes, and generally accepted test methods are not known.

Progress is being made, however. For example, film conditions of the BPR thin film test, which has been found practical for routine testing, much better relate to actual conditions during mixing and laying of pavements than those of the standard loss on heating test. As a research tool, a thin film viscosimeter has been found highly useful to determine values relating to flow properties of very thin film after exposure to controlled conditions, and lends itself to study of durabilities and curing and aging rates of bituminous materials. A committee of the Highway Research Board is occupied in reporting on durability factors of bituminous materials and pointing out avenues for research. And, an Advisory Committee on Asphalt Research for the Highway Research Board has prepared an outline data sheet for recording basic information and recommending minimum amounts of samples of construction material, so these facts and necessary samples might be available for possible later correlation with pavement performance. This latter committee, with its mature and experienced viewpoints, can be expected to summarize methods of approach to lead to realistic requirements for asphaltic bitumen for pavements.

Rheological Properties May Be Important

An additional factor just becoming appreciated is an increasing awareness of the possible importance of the rheological properties of the bituminous binder itself in pavement behavior.[1] The elastic and viscous properties of

asphalts are related not only to the initial density and compaction obtained, which are fundamentals in stability, but also control the densification under repeated traffic stresses and undoubtedly relate to flexural strength. This whole subject has been under active consideration by the Corps of Engineers in relation to airport paving and could well become a factor in design of heavy duty highways of the future.

It is indeed strange that an engineering material with as widespread use as asphaltic bitumen, and which has been used since ancient times as a mortar and waterproofing agent, should still be sufficiently unexplored with reference to fundamentals to permit a rational engineering approach for prediction of pavement design and performance.

Roofing Asphalts — Uses

Uses of asphalt in roofing are manyfold, with large volumes applied as saturant and coatings for the organic fibers, asbestos, and glass felts used in all types of roof construction. In asphalt shingles, which are the most widely used roofing for residential construction, asphalt is both a saturating and waterproofing agent for the felt and provides the water resistant coating and adhesive for the granules.

Built-up roofs, most widely used for business and industrial structures, employ asphalt as the waterproofing medium and bonding adhesive for the felts, and as the weathering surface, with or without mineral coverings. Cold applied asphalt base coatings are available as solvent-cutback or water-emulsified materials and provide ease in handling.

Roofing Asphalt Specifications

Specifications for finished roofing products and for materials used in built-up roofs are provided from government sources and by the American Society for Testing Materials, as well as from trade associations and manufacturers. These specifications are revised periodically to reflect improvements in properties and advances in materials and construction practices.

Some of the subjects under discussion in ASTM committees relate not only to specification requirements and limits but also as to details of test procedures, such as those for determinations of viscosity and cold applied filled coatings used as roof coatings currently under consideration. Laboratory and field testing of dead level asphalts on roofs of low or no slope have shown these products to be highly suitable and dead level asphalts now are generally available, although under a variety of specification requirements. Such materials have been described in ASTM specifications, and more detailed specifications are expected soon from government sources.

"new applications in hydraulics are being developed"

Asphalt Enamels

Asphalt, because of its high inherent water and vapor barrier properties and inert character with excellent weatherability and ability to be economically applied in thick films, has continued to be a better engineering selection as a tough protective film against corrosion. Asphalt enamels for the protection of underground pipelines have recently come into wide acceptance. These are hard, tough, and durable materials usually produced by oxidation to relatively high softening points followed by addition of finely divided, inert mineral fillers. Application temperatures range from 375 F to 550 F.

When manufactured to exacting requirements related both to application and field performance, controlled products have been found completely suitable in protecting pipelines under the most severe soil conditions. As service behavior has become better known, asphalt enamels have become generally accepted as giving full protection for extended times and because of advantages in application and economy are becoming preferred as the coating material.

It is estimated that over 75,000 tons of asphalt base pipe enamels were used in 1957. Recently published specifications for asphalt enamels have become available from the Asphalt Institute and the National Association of Corrosion Engineers.

Asphalt Mastics

Asphalt mastics, cold applied by trowel, spray or brush, enjoy widespread use as protective coatings over insulations and wherever corrosion situations are difficult. Their inherent advantages are numerous, and long weathering films are readily applied economically in thicknesses up to and above 100 mils. Per unit film thickness, their water absorption and vapor transmission properties compare favorably with the best of modern plastics. The thick coatings economically available thus offer maximum protection against corrosion and also often are applied to vessels, as tower bases, to protect against mechanical injury.

Undercoating of automobiles quiets their operation and reduces maintenance cost, and protects fenders and frames from corrosion, especially valuable in coastal areas and where de-icing salts are used on streets. An additional advantage is that air conditioned cars operate cooler because of the insulating effect of the undercoating.

Automobile manufacturers usually list their own requirements for underbody coating, and a federal specification is used for government purchases. Properties usually covered are: Protection from corrosion afforded the steel surface, deadening efficiency, abrasion resistance, low temperature adhesion, application characteristics, and drying time.

Asphalt mastic coatings have high utility in protecting steel tanks and structures from corrosive industrial atmospheres. Coatings formulated with low density fillers to give good insulation properties can be used when heat conservation is important. If a color other than black is desired selected paints have been very successfully applied over the mastic.

Additional areas of use as a vapor and moisture barrier are under the foundations of houses, over industrial insulation, and as a laminant for paper.

Requirements for Vapor Barriers

Many consumers have their own specifications for vapor barriers, but even so products usually are purchased on the basis of satisfactory past experience and reputation of the manufacturer. Low moisture vapor transmission, good flexibility, and minimum straining are important properties for paper laminants. Mastics used to waterproof low temperature industrial insulation should additionally have high resistance to weathering and satisfactory application properties. If the insulation is over a hot pipe or vessel it is important that the vapor barrier not have too low a permeability to moisture vapor to give trapped moisture a path of escape when the installation is brought to operating temperature.

Permeability can be controlled by the selection of fillers used in the mastic or by use of water dispersed bituminous coatings. Subcommittees of ASTM Committee C-16 are active in considering test procedures and properties for accessory coatings over thermal insulations and specifications and test procedures should be forthcoming in the near future.

New Uses for Asphalts

New applications for asphalt in hydraulics are constantly being developed. Asphalt oxidized catalytically with

phosphorus pentoxide[3] has been used extensively in the western part of the country for lining irrigation canals with properties of asphalt thus produced being quite different from that obtained by oxidation without the catalyst. A necessary improvement is greater flexibility at low temperatures to permit deformation with soil movement at freezing without cracking, and this material has been found also to be an economical solution in the construction of stock ponds and pollution control reservoirs. The Asphalt Institute and Bureau of Reclamation have specifications for membrane asphalts.

Satisfactory disposal of radio-active wastes from atomic power plants is a difficult problem which will increase in the future with additional power production, and several types of asphaltic linings have been investigated as linings for storage reservoirs and offer a successful means for containing wastes of low and moderate activity.

Another area of hydraulics in which asphalt shows great promise is in the control of beach erosion. Groins constructed of wood, long used for this purpose, are effective but costly and short lived. In 1954 a number of groins were constructed of asphalt and beach sand in the Ocean City area of Maryland.[4] They now have stood the test of six hurricanes and it is estimated that an investment of $130,000 in these structures has saved the State of Maryland over 10 times that amount in damages from a single storm.

In summary, asphalt's greatest use is in the building of highways, and this is expected to continue, necessitated by our ever increasing need. Asphalt's inherent adhesiveness, excellent age stability, low permeability and rheological properties make it an attractive engineering material for many applications; and additionally, asphalt should have wide potential as a low cost raw material for the production of useful chemicals, with some advance made by laboratory production of ion exchange resins,[1] and with a commercial plant now in operation producing gasoline from a native asphalt.

References

1. Ed. Note: See E. J. Barth, "Asphalt — Prime Roadbuilding Material," *The Refining Engineer*, Vol. 29, No. 4, April 1957, p C-13 for discussion on rheological properties of asphalt.
2. *Chem. and Engr. News*, Vol. 35, September 30, 1957.
3. U. S. Patent 2,450,756 (October 4, 1948).
4. Asphalt Groins, Two-Year Report, *Engr. News-Record*, August 22, 1957. ★ ★ ★

WHAT ABOUT

ADDITIVES FOR ASPHALT?

Warren B. Warden
Miller-Warden Associates

While asphalt has served mankind well for many years as one of our earliest and lowest cost thermoplastics, there are conditions wherein its usefulness can be extended by the addition of small amounts of certain chemicals or other so-called "additives." These are much akin to the familiar VI improvers, pour point depressants, color stabilizers, oxidation inhibitors, lube oil detergents, etc., so commonly used by the refiner in other petroleum products.

The whole field of additives in asphalt is, however, still in its infancy. It is potentially a very broad field which includes, in addition to the much discussed anti-strip agents, a number of "fixes" now available or under test for purposes such as ductility and adhesion improvement, anti-hardening, loss-on-heat, anti-gelling, weathering inhibitors, etc. Whereas the anti-strip additives for cutbacks and cold process paving have attracted the greatest attention to date, some of these other directions will undoubtedly increase in importance in the near future.

Determining the need. The need, or lack of need, for an additive in any given application should be dictated by the service requirements of the whole system or end product in which the asphalt is used. To a very large extent asphalt is used in combination with other materials (aggregates, felts, fibers, fillers, etc.). A modern pavement contains only about five percent by weight of asphalt. Justification for the use of an additive must be related to the serviceability of the entire finished product and not to the asphalt component alone.

Much of the controversy on this whole subject of additives has arisen from an erroneous concept. Attempts have been made to justify additives on the basis of improving asphalt properties whereas the only logical justification can come from an improved finished product of which asphalt is normally but one of many components. In paving, the road determines the need or lack of need for an additive. With a given system of aggregates and asphalt, with a given construction method, and with a given service requirement an additive may be justified. Changing any one of these variables may greatly alter or modify a realistic appraisal of the need and/or economic justification.

To pick a typical industrial application, an asphalt may be used as a flooring saturant, for instance, and here the character of the felt, the processing methods (particularly "stoving" time and temperature) and other considerations in addition to the basic asphalt properties dictate the need or lack of need for an additive. The whole system, not merely the asphalt, should be the yard stick.

This is admittedly a simple and obvious concept, once it has been expressed and appreciated, but lack of understanding to this has resulted in much of the confusion that still exists in testing methods, application techniques, specifications, etc.

The refiner's responsibility. Technology of selecting the correct additive in the correct amount and of properly testing or evaluating the economic justification in a given application has been largely a matter of trial and error. Development of this technology from an art to a science is just starting. It is fully anticipated that use of various additives in many systems involving asphalt for both industrial and paving applications will increase as our understanding and application of the technology of their proper use continues to develop.

It is suggested that the refiner take the lead in this development. The refinery is the logical place for incorporating the additive and the refinery asphalt technologist is the logical coordinator to carry this new science to the field as a technical service function. Intelligent application of sound evaluation principles and full cooperative effort with the chemical manufacturer on the one hand and the user on the other will lead asphalt, as it has the other petroleum products, to broader markets and still greater service to mankind. ★ ★ ★

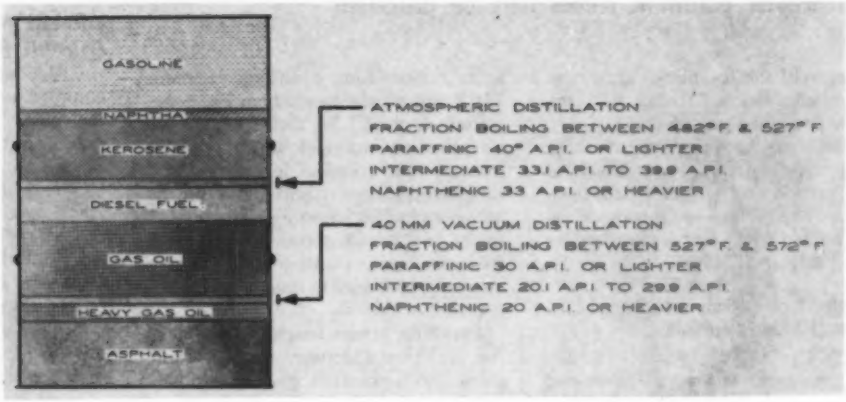

FIG. 1. Bureau of Mines' crude oil classification.

D. W. Gagle
Phillips Petroleum Company

DESIGN AND OPERATION OF MODERN ASPHALT PLANTS

Vacuum Distillation
Solvent Extraction
Bulk Storage
Continuous Blending
Loading Facilities
Batch Blending

ASPHALT for the accelerating highway programs and other uses directs refiners to assess their ability to meet the growing demands of supply and service. Refiners girding to meet this demand find that improved processes, automatic blending and reduced number of grades have overcome some of the objections which once discouraged asphalt manufacture.

In this present era, and more so in the future, high speed construction schedules and a multiplicity of contracts demand simultaneous service and immediate availability of products. These requirements mean that refiners and marketers will have to have the necessary shipping, blending and refining facilities to even further improve the excellent service which has been an important factor in asphalt industry growth. Additionally, now is the time to assess the asphalt potential of the crudes we refine.

Let's explore some of the manufacturing and handling methods available to help meet current and future needs.

ASPHALT MANUFACTURE

Selection of Crude Oils

Early refining methods made easily volatilized low gravity crude oils of the "asphalt" type a prerequisite to asphalt production. Modern processes have so changed this concept that asphalts are now refined from a wide variety of crudes, carefully selected for the specification asphalt they contain but which may have been unrecoverable by earlier refining techniques. By reviewing the nature of asphalt and how crude oils are classified, a better appreciation of the processing variations required will be obtained.

Chemical structure of asphalts. Asphalts are complex hydrocarbons, generally regarded as being colloidal in structure. A chromatographic analysis shows asphalt to consist of asphaltenes, resins and oils. The asphaltene particle has the higher molecular weight, being aromatic and naphthenic, and forms a nucleous or center. Around this core is a protective phase or coating or resin which is less aromatic and more naphthenic than the asphaltene, with some small amount of paraffins. The oils in which the asphaltenes and resins are suspended are usually more on the paraffinic side, varying to the naphthenic and aromatic in some cases. Percentages of each constituent vary in asphalts from different crudes.

Asphaltic crude oil classification. Crude oil classification is helpful in determining the best method of recovering asphalt from a given crude. The Bureau of Mines developed a formula based on the boiling points of certain fractions of the crude. Shown in Fig. 1 is a representative barrel of crude showing an approximate product distribution. By distillation at atmospheric pressure, the fraction boiling between 482 F and 527 F is separated. If the gravity is 40 deg API or lighter, the fraction is termed paraffinic. When the gravity is between 33.1 deg API and 39.9 deg API, the fraction is called intermediate. Below 33.1 deg API, the fraction is designated as naphthenic. Next, distillation under 40 mm pressure is used to select a fraction boiling between 527 F and 572 F. When the gravity is 30 deg API or lighter, the fraction is called paraffinic. Between 20.1 deg API and

"even heavier paraffinic crudes may be attractive"

29.9 deg API the fraction is known as intermediate. Below 20 deg API the fraction is termed naphthenic.

Crudes can be mixtures of these several types such as intermediate heavy fraction and paraffinic light fraction, etc. The greater proportion of asphalts refined today comes from crudes of the intermediate type.

Vacuum Reduction of Crude Oil to Asphalt

Practically all crudes are first distilled at atmospheric pressure to remove the lower boiling gasoline, kerosine, distillate oils, etc. Following this step, selected crudes can be processed to asphalt products by vacuum distillation, solvent extraction, or a combination of both. Air blowing (oxidation) is sometimes used as a subsequent step to secure desired properties.

Vacuum distillation is probably the most widely used residuum reduction process. Referring to the typical flow plan in Fig. 2, topped crude is heated in a tubular heater in order to vaporize the oil to the desired depth of flash in the vacuum tower. Gas oil vapors flash overhead in the vacuum vessel while the non-vaporized asphalt portion is withdrawn from the bottom or "leg."

The vacuum jets and condensers reduce vessel pressure to 10-40 mm of mercury absolute so that relatively low temperatures can be maintained, thus avoiding cracking in the coil and the vessel. Also, vacuum units are designed for short residence time to minimize cracking.

Processing naphthenic crudes. Crudes in the naphthenic class are usually very high in asphalt content and quite easily reduced to the desired consistency. Moderate flash conditions prevail — for example, a crude such as Guadalupe (California) having a 16-deg API fraction from distillation at 40 mm pressure by the Bureau of Mines classification method may only require an atmospheric flash temperature of about 650 F to reach 100 penetration asphalt. At 40 mm pressure, the flash temperature would be about 450 F. With the old time batch still, long residence time at even 700 F temperature could result in undesirable cracking. A modern vacuum unit is better for even these "easy" crudes.

Intermediate crudes require reduced pressure. Reduced pressure is necessary if the intermediate type crudes are to be reduced to asphalt by distillation. A fraction distilled at 40 mm pressure having a characterizing gravity of 23 deg API may very likely require a flash zone condition of about 710 F and 40 mm to produce 100 penetration asphalt. As the API gravity classification increases, lower pressure must be used to offset increasing flash zone temperature requirements. In the above example, lowering the pressure to 20 mm would permit lowering the flash zone temperature to about 670 F. Steam is often used to reduce the partial pressure of the oil.

Paraffinic crudes toughest to process. As gravities approach the paraffinic class, the associated gas oils become increasingly difficult to distill off at pressures above 10 mm. To really get in and dig, very low pressures must be employed.

Ordinarily, the lighter intermediate and heavier paraffinic crudes have a somewhat low asphalt content, sometimes about one or two percent. In a small throughput operation the quantity of specification asphalt is not enough to justify recovery. Larger operations may produce enough to adequately supply an asphalt plant. The increasing availability of natural gas for plant fuel use often makes asphalt manufacture economically attractive.

For example, the laboratory advises that there is good asphalt in a crude having a 31 deg API 527 to 572 deg fraction from Bureau of Mines distillation at 40 mm. They also advise that the gas oils are so high boiling that the conventional vacuum process cannot vaporize them. Flash curves show that a flash temperature of 900 F is required for a 40 mm pressure. At these temperatures, excessive cracking occurs. To lower the temperature to 700 F a pressure of 1 mm is necessary. This calls for high vacuum equipment.

High vacuum operation. Pressures of 1 mm to 5 mm are practical to separate high boiling gas oils from the asphalt. A typical high vacuum operation is diagrammed in Fig. 3. The high vacuum process uses dry vacuum. Flashed gas oil is condensed inside the vacuum vessel by direct contact with circulating oil. Pressure drop between the jet suction and flash zone is held unusually low by careful attention to internal design.

Vacuum jets used in the high vacuum systems are of low volumetric capacity. In effect, this is a built-in way to regulate temperature. Should cracking occur, the jets overload and corrective measures are taken. The clean gas oil overhead obtained is evidence that good separation was made. High vacuum systems are also desirable for reducing topped residues of the moderately-easy-to-reduce intermediate crudes.

Solvent Fractionation for Asphalt Recovery

Crude residues become increasingly complex as molecular weight and boiling point increases. Paraffins, naphthenes, and aromatics may become variously influenced by isomers and side chains — an infinite variety of complexes can exist. Some crudes may exhibit properties such that solvent methods become an economic way to recover the asphalt.

Process fundamentals. Solvent fractionation separates asphalt from topped crude by chemical type and molecular weight instead of boiling point as in the vacuum methods. The process is widely used to recover valuable lube stocks from selected paraffinic and paraffinic-intermediate crudes. Although solvent fractionation is well suited to the really tough-to-reduce crudes, the process can be applied to practically every type crude from which a specification asphalt can be extracted and a clean gas oil overhead is desired. In such general applications, the economics must be compared to other methods. Ordinarily, some vacuum reduction precedes solvent fractionation.

Solvents. A number of solvents can be used for solvent fractionation. Propane is the most commonly used. The liquid propane, carefully controlled by temperature, pressure and solvent to charge ratio, selectively separates the paraffinic constituents from the asphaltic naphthenes and aromatics. Although several approaches to solvent separation can be made, continuous solvent fractionation is an advanced operation that fits the modern scheme.

Process flow. Propane and the residuum charge are contracted countercurrently in a fractionating tower. Propane enters near the tower bottom and the charge about two-thirds of the way up.

A graduated temperature condition exists which continuously changes the solubility of the downcoming oil in the rising propane.

The temperature at the bottom of the tower is controlled largely by the temperature of the entering propane. Steam coils control the top temperature. The bottom propane dissolves paraffinic oil and some naphthenes from the more asphaltic oils. The heating coils at the tower top cause separation of the naphthenic oils from the propane solution. By such countercurrent flow of oil dissolved in propane and the separated descending naphthenic oils, a sharp separation is made between the paraffinic and the asphaltic constituents. The asphaltic concentrate is drawn off to a propane recovery sys-

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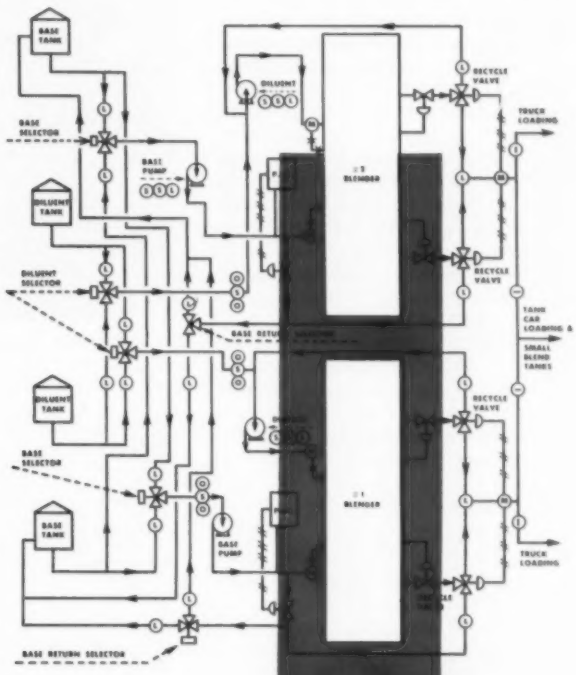

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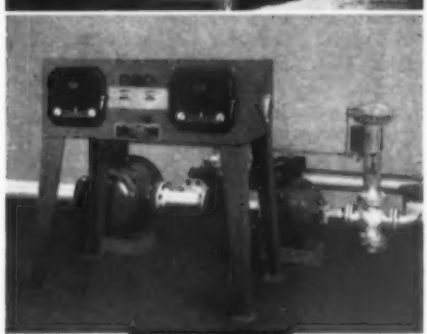

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tem to remove entrained solvent, and from there it is transferred to storage.

Operating conditions. In solvent fractionation, tower pressures are in the order of 450 to 650 psi so the propane will be liquid at the temperatures used. Temperatures will vary, depending on the crude and the end results desired. For example, they may range from about 120 F at the tower bottoms to under 200 F at the top. Propane to charge ratios vary according to the nature of the charge stock. Solvent to charge ratios from 4:1 to 6:1 are commonly used in solvent fractionation. Some operations for cat cracker feedstock employ ratios as low as 2:1. Low temperature operation is desirable and is a plus for solvent fractionation.

Asphalts from solvent fractionation are usually quite high in resin content. Properly made to the desired consistency they are good paving binders and also blend well with regular vacuum and/or air blown asphalts to impart desirable properties.

Air Blowing

Occasionally, a crude may have some high boiling gas oils that an existing vacuum process cannot economically remove. The volume of gas oil may be insufficient to justify equipment revamping for its recovery. Air blowing can often reduce such residues to excellent paving asphalts by blowing with air at elevated temperatures, about 425 F to 550 F, until the right consistency is obtained. Many highly desirable paving asphalts are produced by air blowing operations supplementing vacuum reduction.

Chemistry of the process. The blowing reaction is mainly dehydrogenation. Oxygen from the air reacts with hydrogen from the oil to form water vapor. The progressive loss of hydrogen polymerizes or condenses the asphalt to the desired consistency. Some hydrocarbon vapors are also taken off along with the spent air and water vapor. After reaching the desired temperature level in the still, very little heating is required since the reaction is exothermic. In some cases cooling measures are necessary to keep the temperature under control.

Batch and continuous operation. Blowing may be batch or continuous. Batch blowing is usually done in horizontal and vertical stills. The older horizontal stills, because of the low liquid head, can use low-pressure blowers from the air source. Air is introduced by means of perforated pipes. The newer vertical stills require higher pressure air. The vertical still has the advantage of better air utilization through longer-air-asphalt contact time. In batch operations a fired heater is ordinarily used to obtain the blowing temperature. Continuous processes are usually engineered around one or more of the vertical type stills.

When the asphalt charge comes directly from a refining unit, such as the vacuum tower bottoms, no fired heater is used. Recirculation of a portion of the blown asphalt is an effective control feature and the balance is withdrawn continuously to storage. Steam blanketing of the vapor space in the blowing still is usual for all types of blowing, both from a safety standpoint and for the cooling effect.

Blowing with air is a process also extensively employed to make high quality specialty asphalts for roofing, pipe coatings, prefabricated lining products and the like.

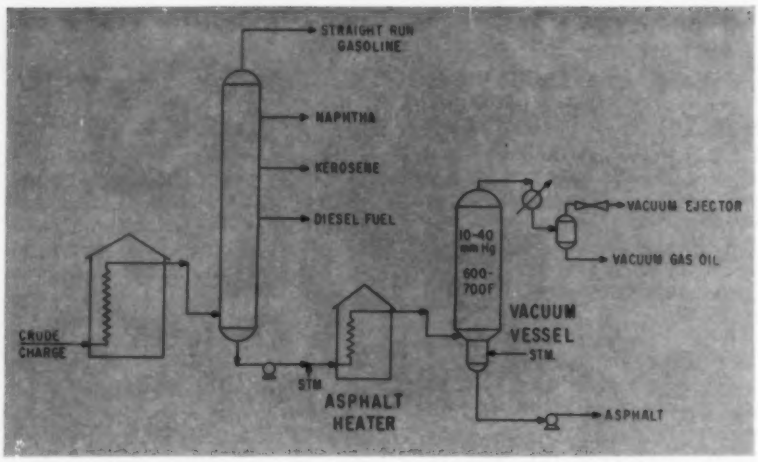


FIG. 2. Atmospheric and vacuum distillation unit process flow sketch.

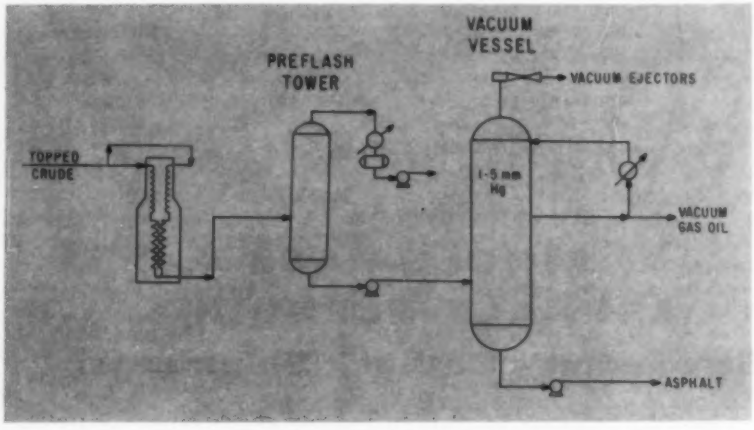


FIG. 3. High vacuum distillation unit.

PROCESS OFF-SITE FACILITIES: ASPHALT SERVICE

Storing, transferring, blending, loading. These sum up the most important aspects of the asphalt business — SERVICE. Now, more than ever before, service is necessary to increase the use of asphalt for the Federal Highway Program. Here are the major considerations on items concerned with the operation of an asphalt plant.

Field Storage

Total volume of field storage needed depends upon production rates, marketing conditions and seasonal variation in sales. Usual capacity for each tank is 25,000 to 100,000 bbl. Welded steel tanks are generally used, with construction conforming to API codes.

Provision must be made for heating. Tanks may be insulated or not, but in every case provision must be made for heating. There is a wide choice of heating methods, all good, but dependent upon personal preference and local conditions. When the field storage tanks are conveniently grouped, a centrally located fired heater can be used to heat the tanks, alternating as needed to maintain the required temperatures. For most applications, a 6

million Btu/hr heater is satisfactory — 10 million Btu/hr for some larger operations.

Where storage is scattered, individual tank heaters are often used. These may be the simple internal flue type consisting of a horizontal firing tube extending across the bottom of the tank and then rising vertically through the tank roof to form the stack. (Asphalt should never be allowed to get below the level of the firing tube during heating.)

Some external fired individual tank heaters are also used. These supply heat to a shell through which the asphalt is circulating.

If steam is plentiful, steam coils, bundle type suction heaters, finned tube heaters, circulating line heaters, are all useful. Circulating hot oil heaters have been used with considerable success in some installations. Cost-wise, the fired heater is advantageous, either external, internal or a central unit.

Should tanks be insulated? A decision to insulate field storage tanks should take into consideration the manner in which they are to be used. There is some question as to the value of insulating tanks that are to be dormant for long periods of time and then subject to rather large volume transfers. To some extent asphalt forms its own insulation to the level of the liquid.

A short period of heating with an external fired heater to bring the tank to

"service is the most important aspect"

transfer temperature may not result in sufficient heat loss to justify cost of insulation. In many cases suction heaters are used with uninsulated tanks. Moderate heat from steam coils keeps the asphalt fluid enough to feed the suction heater inlet. The size of the suction heater must be based on the transfer rate and outlet temperature desired. Designing the suction heater too small would necessitate a higher overall tank temperature. Should this situation occur, tank insulation is necessary to cut down heat loss.

Field storage tanks that are subject to frequent withdrawal should be insulated. Tanks so used are actually working tanks. For best results, these tanks should be equipped with suitable mixing devices such as electric mixers, eductor mixers on the circulating pump discharge or even air spiders. Maintaining on test, uniform consistency asphalt is extremely important in field storage that is active in serving a blend plant.

Base Stock Transfer Facilities

Pumps. Inadequate base stock transfer rates are a serious bottleneck in asphalt plant operations. Base stocks should be moved at high enough transfer rates to prevent blend plant tie-ups. Careful attention to pump and line sizing is mandatory to balance an operation. Type of equipment is optional. Some plant operators prefer steam, others electric powered pumping equipment.

Widely used throughout the industry is the electric driven positive displacement gear pump. Freedom from pulsating flow makes the positive displacement gear pump best suited for highly instrumented operations such as continuous automatic blending. Pumps must have sufficient capacity to do the job.

Transfer line heating. Whenever possible, transfers are kept above ground. Buried lines are difficult and costly to maintain.

Lines handling viscous asphalt will require some type of heating and insulation. Insulated, steam jacketed lines are probably the most effective, particularly where very viscous, low penetration asphalts must be moved. The disadvantage of steam jacketing is the high initial cost and maintenance problems.

Internal or "gut" lines are very effective but their popularity suffers with the type of maintenance too often needed. Steam or condensate leaks from jacketed or "gut" lines can carry

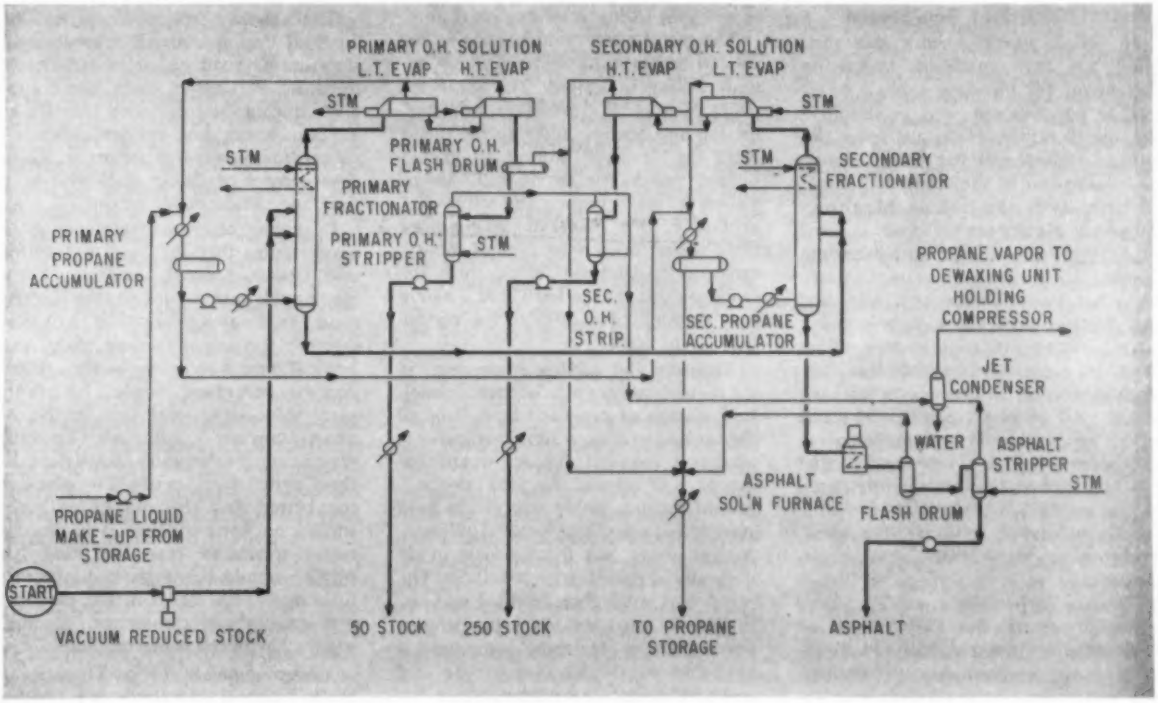


FIG. 4. Propane deasphalting unit.

"proper equipment can speed transfer operations"

miseries on into the blend plant. Dehydration of blends, cleaning up spills, and, sometimes, serious damage to tankage, can result from the water and asphalt treatment. To avoid the leakage problems, steam tracing is advised. A typical tracing installation for a 4 in. transfer line would utilize a ⅜ to ½ in. copper tubing or steel pipe attached to the transfer line which is then covered with 5-in. moulded insulation.

An interesting improvement is suggested by the use of certain putty-like heat transfer materials which can be troweled to fill the voidage around the tracer line. Heat exchange approaching the level of steam jacketing is claimed at much less cost.

Electric line heating is coming into the picture. Where codes permit, it will be worth investigation. Used on the "gut" line principle or traced outside the line an electric heating cable suggests interesting possibilities and economies.

Fill or circulating lines should not discharge overhead into the vapor space of the storage tank. In the refining industry, overshot filling of any hydrocarbon storage tanks is not considered good practice. Where discharge near the liquid level in the tank is desired, adjustable swing lines are recommended.

Product Blending Equipment

In recent years, considerable progress has been made in improving equipment for blending asphalt products to specification, and in simplifying specifications. Here are some design considerations for blend plants, and discussion of the equipment used.

Batch and continuous blending. Blending plants are of two general types, the conventional tank blending system and continuous automatic blending. Tank blending is widely used and has not changed much in concept from early operation other than refinements of equipment and facilities. Purchasers' inspection procedures initiated at the start of tank blending years ago often became so firmly implanted in the necessary operational scheme that an improved system of blending could not be used regardless of the manufacturer's inclination to do so. Even now, many new installations are so influenced.

Despite inspection handicaps, tank blending can do a fine job of supplying the customers needs. A blend plant operator must have an almost pathological awareness of the need for timing. Delay is costly. The laboratory must know the materials so that blend formulas can be accurately made. The blend plant operator knows that inaccurate gaging, errors in meter computations and transfer of wrong materials carry headaches and penalties beyond human endurance. The efficient asphalt plant has separated the men from the boys.

The general layout of a blend plant should be as compact as possible. Lower construction costs, closer operating control, and greater overall efficiency from the service standpoint are the benefits.

Batch blending design. Following the flow of the base asphalt from field storage, the first requirement is tankage to blend asphalt cements. Usually, blend tanks in the order of 5000 bbl to 25,000 bbl or more capacity are recommended for the faster moving grades. Slower moving grades can utilize 500 to 2500 bbl tanks. Capacity is governed by careful planning for the volume to be handled with full consideration to the peak demand periods.

Inspection and testing time requirements must not be overlooked in determining optimum tank sizes. A pitfall exists in using too small tanks for fast moving products. Two tanks for each grade are not always economically feasible or geographically possible — refer again to the emphasis on timing.

The blend plant tanks should be insulated except in those cases where actual cooling is desired. The same aspects of tracing, insulation, transfer, mixing and heating apply to the blend plant as to field storage. Jacketed pumps and valves or liberally steam traced standard pumps and valves are necessary. Most plants use an auxiliary fired heater to keep the asphalt cement tanks at the desired temperature for loading or at such a level that a single pass through the heater to the carrier will do the trick.

Transfer and mixing equipment. If the manufacturing plan permits enough field storage of pretested asphalt in all the needed grades, a simple transfer is all that is required. Inspection and approval will release the tank to load. Manufacturing plans may divide field storage between, say, a 200-300 penetration grade and the heaviest grade normally supplied, such as 40-50. The blend tank must then be filled successively from each tank with the proportions gaged in. Metering equipment is available to aid in saving time and make more accurate blends.

Metered transfers made simultaneously lessen mixing time. By use of ratio flow control equipment, the smaller volume transfer can be extended to the same time as the larger volume and very little mixing is required to bring the tank on test when meters are not used. Electric mixers working during the filling operation of the second gaged transfer will speed this type operation. On simultaneous metered transfers, the mixer operates for the duration of the filling time. When the transfer is complete the tank is ready for the laboratory to test. Also, direct metered transfers through the internal jet type mixers will accomplish the same purpose.

Air mixing should not be sold short; it is a good way to mix asphalt cement blends if properly controlled. Air mixing should not be prolonged, however, as changes in consistency may result. Also, condensed moisture in air lines can cause trouble in a hot asphalt tank. Knockout drums, driers or other means may be provided to keep entrained moisture controlled.

After mixing the tank is ready to sample. Samples should be obtained directly from the blend tank itself.

Blending cutback asphalts. Rapid curing cutbacks (RC's) are base asphalt cut with naphtha type stock — about 250 F to 400 F boiling range. Medium curing cutbacks (MC's) are base asphalt cut with a kerosine type stock, usually about 325 F to 525 F boiling range. Slow curing road oils (SC's) are usually base asphalt plus suitable gas oil fluxes.

Tank blending of rapid curing and medium curing cutback asphalts and slow curing road oils is best done by metering the cutter stock simultaneously during the base stock transfer at a point where line contamination of succeeding blends will not occur. Ratio flow control of cutter stock will save time and assure better mixing.

In some instances, circumstances may require that the base and cutter stocks be transferred separately. If so, placing the cutter stock in first is often used to minimize loss of volatiles through the initial cooling effect and gradual temperature rise as the asphalt content increases. Some, however, place the cutting stock in after the asphalt transfer is complete. To save argument, a laboratory distillation of the finished blend will show which is the better way. Mixing of cutbacks should be done quickly. The electric mixer or eductor types are good. Air mixing should be of short duration if used. Loss of volatiles in RC blending will obviously be greater with air mixing than with the other methods.

Losses of cutter stocks. There is actually less loss of volatile constituents in larger capacity storage than in the

smaller 500 to 1000 bbl tanks. For most operations slow moving grades and unusual specification requirements make some small storage units desirable. The slow moving stocks should be made up in the quantity and at the time they are to be sold. These stocks should not be kept overly long in storage as overblending and patching will have to be done, truly a nuisance procedure. A few small storage tanks should be available for this kind of business.

Loading Racks

Central island type loading racks are the easiest to handle. Load spots remote from each other are inefficient and time consuming. Loading should be centralized if at all possible with separate load lines for each type of product. Separate lines for each grade are unreasonable. In a well engineered plant, lines will be short so that contamination will be minor or line cleaning by blowing back with air can be easily done.

Loading speed. How fast to load? When 10 or 15 trucks all want the same grade loaded at 7 a.m. careful scheduling is the answer. Too fast loading rates are hazardous to small capacity carriers. Too slow rates delay the larger carriers. About 300 to 350 gpm is a reasonable rate for most operations, with many plants doing a fine job on 200 gpm. Anything in excess of 400 gpm would require special attention. Safety hold down devices should be provided for the loading spout. Hydraulic actuated arms are good — so are chains. Regardless, some means must be provided.

Metering load-outs. A set-stop meter is a good watchdog for the loading operation as well as a transfer record. Even though sales are made on a weight basis, taring the carrier before and after loading, a set-stop meter will be valuable. Fickle load limits often require loadings below the calibrated markers on some carriers. Here the set-stop meter comes to the rescue. Again, it is insurance against spills. Loading to the marker can be difficult due to vision obstructing fumes — the last few inches come awfully fast.

A consistency check and flash on retain samples taken immediately after the load is completed are usually sufficient to satisfy that the right product is loaded. Ordinarily trucks need not be held during such testing unless local inspection requirements insist.

Continuous Automatic Blending

Continuous automatic blending of asphalts offers relief for many of the headaches encountered in tank blending. Present day developments in instrumentation, proportioning, equipment, control devices and the like, now

"continuous blending relieves many headaches"

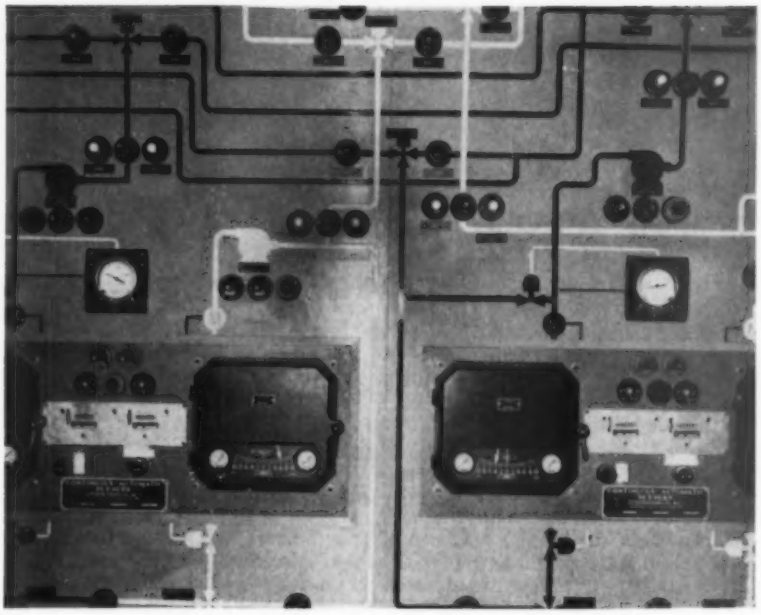


FIG. 5. Control panel for continuous automatic blending unit.

make it possible to apply the same precision to asphalt blending as has long been practiced with light oil blending. This is a type of blending more manufacturers should investigate. With the highly instrumented automatic plant, service is at its optimum.

The first requirement for the automatic plant is sufficiently large base storage to keep demands satisfied without delay. In many cases, the same base asphalt will be used for both RC and MC cutback types. Having two tanks for each base will permit continuous operation. One tank can be filled while the other is being withdrawn for blending and loading.

Precautions for continuous operation. Of utmost importance — know the base asphalt. Base stock tanks filled from unmixed field storage or directly from unit operations can vary enough in consistency to defeat the precise blending which is the valued feature of the automatic plant. Base stocks must be thoroughly mixed, completely tested and the temperature level carefully maintained. The blender base tanks should be insulated and all lines, valves and pumps properly traced or heated.

Next, the blender should be located at a central loading facility so that all operations concerned can be handled in the shortest time. Remote control of valves and pumps will enable the loaders to remain at the loading dock.

How does this automatic system work? Base asphalt is pumped to the blender and back to the tank by means of a recirculation line. Cutting stock is transferred from pretested and approved storage to the blender. Recirculation in this case is from the pump back to the line. With flow established, a proportioning mechanism combines the base and cutter stock through a short turbulent mixer section and thence is metered into the carrier. The completed load is sampled and tested and goes on its way.

The blenders utilize temperature compensated meters on the base and cutting stock circulating lines. Connected to the meters are drive shafts to the proportioning equipment operated from a control panel. Predetermined settings are made to establish the flow rates of the blend components. The blender is then turned on, motor actuated remote control three way valves direct the base and cutting stock through the mixer, meter and loading assembly into the truck or tank car. If the set proportion is distributed in any manner whatsoever, the operation goes immediately to recycle. In order to keep the asphalt flow in the proper channels, the recycle line valves are electrically interlocked with the pump suction valves so that the recycle flow goes back to the same base tank.

Control panel. A typical proportioning control panel is shown on Fig. 5.

Lines show the flow and lights indicate the status of equipment operation. Control points for operation of three-way valves, flow control indicators and proportioning dials can also be noted.

The set-stop meter automatically closes off when the load is completed. Immediately, the blender goes on recycle operation and is ready to reset for the next load. The automatic features of the system leave the loader sufficient time to handle the necessary paper work so that upon completion of the load the often numerous clerical details will be out of the way.

Refinements to the system. Some additional refinements can enhance the value of the automatic blend plant. Automatic printing of the separate components of the blend will go a long way to establish good customer relations. This is particularly true when purchaser's inspection is made on the base and cutter stock tanks. It provides a record of the whole transaction. Continuous viscosity recorders can be engineered to show a consistency record of each load. Likewise, temperature recorders show the average load temperature and spare the loader this routine check by thermometer. Should sales be by weight, the weight recording apparatus should be located at the dock and the tare printed before and after loading.

Automatic blending of asphalt cements. The same automatic blending can apply to asphalt cements. A good set up for an average operation would employ two proportioning units for the cutbacks and road oils and two proportioning units for the asphalt cements. This gives four spot loading of four different products at the same time. With no grade storage to worry about, the customer can come at any time for any grade he desires. Careful scheduling of trucks eliminates tie ups in peak periods. It is a good way to operate and has so many real benefits for the customer as well as the manufacturer, that a great future for automatic blending is predicted.

Laboratory requirements. A laboratory is necessary for the operation of a blend plant. Here are the people who control manufacture and guarantee the product quality. Specifications require that tests be run. A close alliance with the laboratory gives the blend plant operator an opportunity to intimately know the materials with which he is working. From the crude tests through frequent routine control tests during manufacture to routine storage evaluations, research studies, formulations, blend testing and finally loaded product sampling and checking, the chemist is the responsible man.

Conclusions

Processing and handling of specialized asphalts such as emulsions, roofing fluxes, etc., have been by-passed in order to give general coverage on a standard installation. The points we wish to bring out are these: The highway program will demand more and more asphalt products. There are crudes containing good asphalt and ways to get it out. Are we taking full advantage of the tools with which we have to work? Service is the key to successful blend plant operation. Service totals a coordinated effort from manufacture, field storage, blend plant operation to customer loading; all this under the quality control measures of the laboratory. ★ ★ ★

Solvent extraction processes showing the way to...

TAILOR-MADE ASPHALTS

Edwin J. Barth *Asphalt Consultant, New York City*

PROPERTIES OF ASPHALTS made by vacuum and/or steam distillation depend primarily upon basic properties of the crude processes. One exception, of course, is the modification of roofing asphalts properties by air blowing (oxidation).

Use of selected crudes is, of course, common practice for making the usual grades of asphalt. Many refiners have "asphalt-rich" crudes available, and are able to use them to great advantage. Also, certain mixed-base crudes are being used for asphalt production and, for certain uses, it is often possible to make enough finished grades for the refiner to be established in the asphalt business.

On the other hand, a refiner using only light crudes will not have quality asphalt in sufficient amount to make asphalt manufacture feasible, using the more commonly accepted methods of asphalt recovery and refinement.

Present-day solvent extraction processes and others in development stages enable asphalt manufacture from crudes of almost any basic type, including paraffinic. Solvent extracted asphalts are relatively free of deleterious wax and high boiling ceresins that are quite undesirable in paving asphalts.

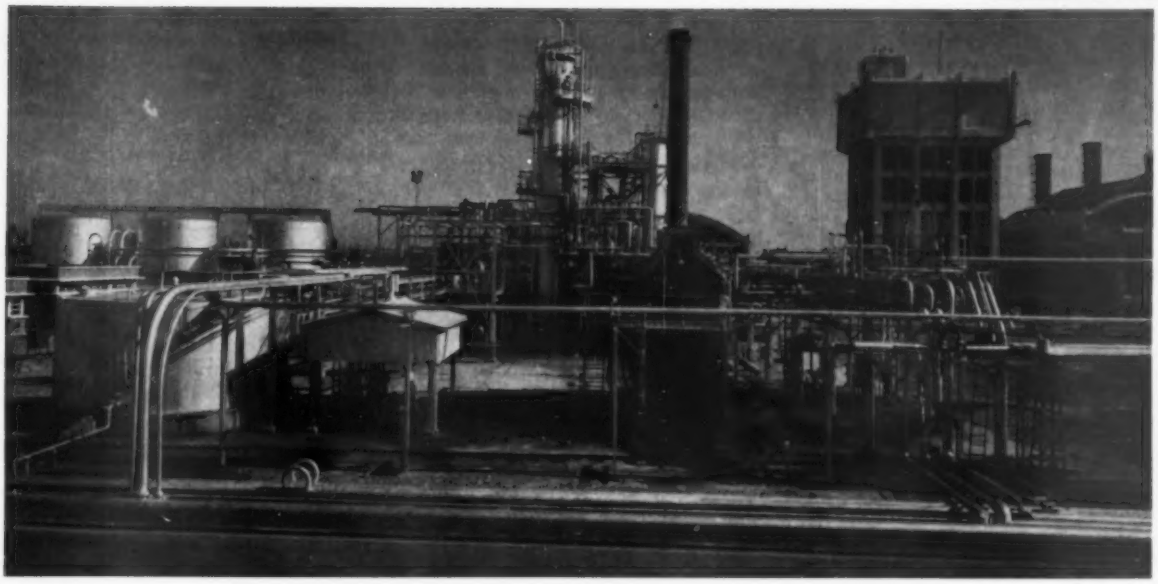
Since solvent-extracted asphalts are separated according to their affinity for the solvent rather than by boiling point, chemical structure of the molecule can be more or less controlled. And, since operation is at relatively low temperature, there is no rearrangement of the bitumen molecule or incipient cracking as evidenced by a positive Oliensis spot test.

By recombining asphaltenes precipitated in solvent processes with selected resins and solvents, "tailor made" asphalts are created. Thus the asphalt blender can employ the same basic techniques used in motor fuel or heating oil blending to obtain predetermined properties. Further, it is possible to blend "tailor made" asphalts that will fit almost any reasonable specification, and therefore fit them specifically for their intended application. In many instances, asphalts can be made with properties otherwise impossible to achieve with more conventional processing of a given crude.

The Raw Materials

Components used for blending synthetic asphalts are, more or less, the constituents of asphalts themselves. The difference from normal procedure is that raw materials are derived from propane deasphalting and from other solvent extraction processes rather than from vacuum distillation of an asphalt-rich crude.

These raw materials can be classified as propane precipitated asphaltenes (hard or soft), resins, and various high and low-aromaticity solvent extracts. They are blended to suit certain rheological requirements for applications



— Courtesy The Lummus Company

This propane deasphalting unit produces components for tailor-made asphalts.

as exacting as those for steel, concrete, plastics, and other engineering materials of construction. Since they are blended with materials produced by low-temperature processing, problems generally occurring in dealing with heat-sensitive, high molecular weight asphalts are avoided.

Basis of the Process

Raw asphaltenes derived from deasphalting lube oil base stocks are formulated with other materials to attain precisely calculated properties in the finished products. Other blend components include resins or resinous petroleum fractions and — possibly — addition of a wide variety of preferably high aromatic content by-product extracts. The latter are derived from solvent processes, of course, and may be of any viscosity or viscosity index range.

For example, asphalt derived from a soft Mexican residual shows, by one method of "group analysis":

Insoluble asphaltenes	16.0%
Semi-hard resins	27.0%
High-boiling oils	57.0%

Theorizing, if we have these same components segregated in tankage, we can blend them to achieve a homogeneous solution that will have, within the limits of experimental error, the same properties of the initial asphalt.

Using these same components in different blend proportions, we can make "asphalts" with entirely different properties. Wilhelmi,[1] in 1932, was the first to show how asphalt properties are affected, as well as their rheology, by changing the composition of the bitumen. Following discussion of the basic components, properties that can be achieved in synthetic blends are presented here.

Propane Asphaltenes

Propane asphaltenes are most often rated as to their melting point and penetration; other tests should be made, however. Propane asphalts derived from Middle East reduced crudes show the following properties:

Generally these materials fall most commonly within:

Penetration at 77	0-10
Melting point (R & B)	150-300 F

They are very hard and friable and not always entirely free of adhering resins.

Resins

These materials as produced in most de-resining operations are brownish to

	From 31% Reduced Crude	23% Reduced Crude
Melting point (R & B) F	144	161
Penetration, 77 F	21	10
Sulfur, percent	5.81	6.12
Insoluble in 86 deg paraffinic naphthas	16.0 percent (low)	21.0 percent (low)
Soluble in carbon disulfide	99.8 percent	99.8 percent
Oliensis spot test	negative	negative
Penetration-index (Shell)	—0.3	0.0

TABLE 1. Properties of "Natural" and "Synthetic" Asphalts.

REDUCED FROM—	Iranian	Arabian	Venezuelan	Synthetic asphalts from reduced Arabian crude (penetration)		
Reduced crude (%)	19.0%	12.0%	51.0%	100–200	85–100	Hard
Penetration, 77 F	180	210	160	180	91	19
Melting point (R&B)	100 F	soft	106	103	114	194
Ductility, 77 F (cms.)	100+	100+	100+	100+	100+	4.0
Fraas breaking point	—13 C	—15 C	—19 C	—15	—13	—8.5 C
Asphaltenes (60/80 C)	3.5%	4.6%	14.7%	19%	23%	35%
Resins	55.0%	57.0%	45.0%	43.0%	38.5%	—
Paraffinic oils	40.0%*	—	12.0%*	16.0%	20.0%	—
Aromatic oils (approx)	15.7%	12.7%	32.0%	26.0%	21.0%	—
Wax (Holde)	3.5%	4.4%	1.1%	1.0%	0.9%	1.9%
Sulfur	3.3%	2.7%	4.8%	below 1.0%	below 1.0%	—
Penetration index (Shell)	—1.6	—	—0.6	—0.8	—1.0	3.0

*Approximate.

black, though from certain fractions they are quite light in color, and are highly adhesive semi-solid to solid materials. Penetration may vary from hard to over 200 penetration, with melting points generally in the region of 100 to 150 F. They are almost completely soluble in low boiling naphtha, normal benzine or 86 deg Pennsylvania naphtha.

Solvent Extracts

These fractions from various lube oil solvent operations vary in viscosity, are usually quite low in viscosity index, contain a good amount of high boiling range aromatics, and show strong solvency toward the other components to be blended with them. They usually contain liquid or semi-solid resinous materials which are usually not removed as such.

Asphalts from Intermediate or Mixed-Base Crudes

Mid-Continent crudes, similar to many of the world's mixed-base crudes, usually furnish asphalt of a sort with low yields. Exceptions are, however, to be made to this statement in that some Mid-Continent crudes do furnish asphalts that have fair to good quality — but their uses are confined to a few grades that cover at most a restricted number of applications.

Effect of Molecular Weight

Molecular weights of asphaltic components vary considerably depending on the origin of the groups; these variations considerably affect the behavior of the blended asphalts. The resin fractions, however, exert a more pronounced effect than do the oily and asphaltene groups.

	Fractions from Mid-Continent reduced crude	From Panuco reduced crude
Asphaltenes	2500—2700	2833
Resins (hard)	869	1179
Heavy oils	660	470—500

Blend Calculations and Results

Useful measurements for carrying out the process of making synthetic asphalts and to distinguish the nature of the oils are refractive index, specific gravity, UOP factor and viscosity index along with viscosity. High UOP factor, low specific gravity, high VI indicate their paraffinic nature, while highly aromatic oils are characterized by high specific gravity, low VI, and a low UOP factor. Extracts vary in viscosity from thinnish dark brown liquids of 30 to 40 seconds Saybolt Furol to very viscous liquids or even semi-solids of over 300 seconds at 210 F.

Comparison of Natural and "Synthetic" Asphalts

Table 1 contrasts two Middle East residues and a Venezuelan heavy reduced crude with three "tailor-made" asphalts compounded from Arabian crude components.

Table 2 shows properties of asphalts tailor-made from a Mid-Continent crude. They resemble closely Panuco asphalts, an asphalt that is rated as one of the best made by more conventional methods. It has given top service in pavement construction for many years; with the addition of small amounts of oil, the 17 penetration material (Blend A) can be formulated into several grades of asphalt cements.

Use of aromatic extracts and low VI resins is desirable due to their solvency for asphaltene material; they also aid in securing high ductility. Penetration index of the blend may have to be adjusted.

With the judicious selection of proper extracts, air-blowing the blend will not be necessary. We find that air-blowing increases particle size of the dispersed asphaltenes, which could lead to materials showing so-called "structure" even at elevated temperatures and low ductilities.

Work carried out abroad, shown in Tables 3 and 4, shows the broad range

TABLE 2. Tailor-Made Asphalts from Mid-Continent 23 Percent Reduced Crude.

	Resin	Propane asphalt	Blend (A)	Resin	Propane asphalt	Blend (B)
Vol. % on reduced crude	8.9%	9.3	18.6	20.0	8.3	29.0%
Specific gravity at 60 F	1.005	1.083	—	—	1.088	—
Melting point (R&B) F	109	216	152	Soft	209	119
Ductility, 77 F	100+	0.0	18 cms	Soft	Too hard	100+ cms
Penetration 32 F	—	—	6	—	—	15
Penetration at 77 F	193	1	17	Soft	0	62
Penetration at 115 F	—	—	89	—	—	Too soft
Pen-index (Shell)	0.3	—	—0.2	—	—	—1.1
Susceptibility ratio of penetrations	—	—	1:2.8:14.8	—	—	1:4.1:-
Sol. 86 deg par. naphtha	100%	50%	76.2%	100%	41%	84.4%

TABLE 3. Synthetic Asphalts.
(Components from 178 Pen. reduced asphaltic crude.)

Blend	Resins and oils			Asphaltenes			Resins and oils			Lagunillas steam reduced asphalt
Penetration at 77 F	106	100	60	95.	2.0	68	96	99	90	95
Melting-point (R & B) F	114	110	110	123	206	171	118	211	170	115
Pen-index (Shell)	—0.4	—1.4	—1.0	0.7	0.8	4.7	0.1	8.6	5.6	—0.8
Ductility, 77 F	100+ cm	100+	100+	90	10	40	100+	10	30	100+
Ductility 39.2 F*	12	76	0	5	0	3	16	2	2	13
Spot test	Neg	Neg	Neg	Neg	Neg	Pos	Neg	Pos	Pos	Neg

Note: Asphaltenes used show zero penetration, and 96% matter insoluble in 86 deg Pennsylvania naphtha.
Resins showed 60 pen, 115 F M.P. and 11% insolubles in 86 deg Pennsylvania naphtha.
*5 cm/min.

TABLE 4. Synthetic Asphalts.
(Components from 160 pen. reduced Middle East Crude — Intermediate Base Type.)

Blend	Resins and oils			Asphaltenes, Resins and oils			Panuco-steam reduced asphalt
Penetration, 77 F	90	100	58	96	90	100	100
Melting-point (R&B) F	120	106	120	188	123	120	118
Ductility at 77 F	100+	100+	100+	63	100+	100+	100+
Ductility at 39.2 F*	6.0	9.0	0.0	5.5	9.0	9.5	9.5
Pen-index (Shell)	0.0	—2.1	—1.2	7.1	0.5	0.4	0.0
Spot test	Neg	Neg	Neg	Pos	Neg	Neg	Neg

Note: Asphaltenes used showed 97% insolubles in 86 deg Pennsylvania naphtha.
Resins used showed: M.P. (R & B) 121 F, penetration at 77 F, 52; 4.1% insoluble in 86 deg Pennsylvania naphtha.
*5 cm/min.

of properties possible in synthetic asphalts. The asphaltenes were obtained by the use of hexane, the resins and oils from propane de-asphalting.

Processes can employ light fractions such as pentane, or mixtures of propane and butane, as well as hexane or straight propane for preparing the asphalt.

Asphaltenes and resins furnish a plastic property to these blends, as they do in vacuum reduced asphalts. This term is most loosely applied and will be ill-defined until research reveals the interrelationships of rheological properties of bitumens. It is believed the resins exert a far greater effect on asphalt properties than the oils or the asphaltenes. Physico-chemical function of this group has been described.[4]

Of immediate interest to the asphalt technologist is the fact that the resin group supplies ductility to the blend, but brittleness also, especially at low temperatures. The latter, often an adverse property when working in the low-temperature region of application work, calls for care in formulation. Furthermore, the resins produce various effects as to temperature susceptibility, depending on their viscosity. It appears that they also exert an influence on stripping resistance.

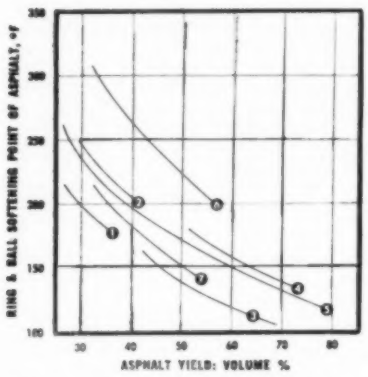


FIG. 1. Asphalt yields of reduced crudes vs asphalt melting point (R&B).[2]

Curve No.	Reduced Crude	Vol. % of Crude
1	Canadian	20.0
2	Canadian	16.0
3	Kuwait	32.2
4	Kuwait	22.2
5	Arabian	16.0
6	Venezuelan	25.0
7	Texas	11.1

Those versed in asphalt technology will recognize in the above data properties of synthetic asphalts that appear practically identical to the well-known Panuco asphalt, considered a standard for quite a number of years. Other asphalts giving good service over the years are indicated by resemblance to Lagunillas asphalts, California asphalts, and certain types of Mid-East asphalts. None of these blends required air-blowing to secure the properties tabulated.

Asphalts from Decarbonizing Operations

Modern decarbonizing operations for the preparation of cat feed stocks also employ mixtures of propane and butane. As by-product from these operations, synthetic asphalts are produced that show extremely desirable properties. They are practically wax-free, and generally pass the spot test because they are obtained by relatively low-temperature operations.

These operations produce as high as 240 F melting point by-product asphalt. Decarbonized asphalts are also "tailor-made" materials. One can reverse the operation to primarily control the synthetics, allowing the quality of the decarbonized gas oil or cat feed to be variable in the process. By judicious control of operations and variables, softer or harder asphalts can be produced.

As an example, one such process[2] thus produces asphalt, for instance from:

1. Canadian 16 percent reduced crude (32 percent asphalt on reduced oil), 224 deg F, SPT.
2. West Texas asphalts (6 percent of crude charge), 196 deg F, SPT.
3. Middle East asphalt (from a 32 percent reduced crude), 16.9 percent of 132 deg F, SPT.

Fig. 1 shows yields of solvent asphalts vs melting point.[2]

Conclusions

As to blending techniques, one may blend without the oils in many cases, or again without added resins, if the extracts contain resins already in solution. Blending is a controlled procedure, wherein components are measured accurately by blending meters to controlled automatic pumping facilities and metering devices.

Solvent processes mentioned are especially valuable for those refiners operating on mixed-base crudes, which are either deficient in vacuum distillation-type asphalts, or are difficult to handle due to their sensitive or heat-instability nature. Such crudes will yield any type asphalt not found in the crude oil "as is." Often such crudes show heat instability by the positive Oliensis spot test made on the residue.

On the other hand, for those refiners already in the asphalt business making distillation or steam-reduced asphalts, the new processes furnish valuable material for blending into their regular grades enhancing the latter as to quality and securing special properties of the asphalt not otherwise obtainable.

The manufacture of synthetic or "tailor-made" asphalts by these methods achieves one of the prime objectives in the asphalt industry — namely, to make asphalts under absolutely controlled conditions and formulation of definite properties such as are desired to fit them to exacting specifications. These asphalts, as with the new lubricants presently coming into the market, are "tailored" to the specific application for which they are being sold.

The processing to obtain these objectives, in summary, comprises:

1. Recovering asphalts of high quality at low to medium temperatures, avoiding splitting reactions.
2. Manufacturing asphalt reasonably if not entirely free of paraffin wax.
3. Obtaining fairly definite commercial fractions from refinery operation — whose control is not difficult, and whose make-up approaches closely the asphaltenes, resins, and oils found in petroleum asphalts.
4. Manufacturing asphalts under controlled conditions, and exact proportioning of ingredients to make products of all shades of variation as to properties and rheological characteristics; such products to fit into modern scientific engineering specifications for paving, roofing and the specialties.

New products such as those now being manufactured by the above-described methods are being tested in new researches investigating rheological behavior and other interrelated properties, along the lines described by the writer in a previous issue of The Refining Engineer.[3]

Using these new methods to produce synthetic or so-called "tailor-made" asphalts, the refiner should be in an excellent position to enter the asphalt market, or augment with additional products those he already produces. He will be able to supply the trade with asphalts of high quality to give first-rate performance in the field.

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PETROCHEMICALS VIA THE OXO PROCESS

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Part 2. *Technology of the Oxo Reaction, Production of Aldehydes and Alcohols*

THE MAIN course of the Oxo reaction yields two isomeric aldehydes by the addition of carbon monoxide and hydrogen to an olefin bond as given in Equation 1.

Conversion is (normally) effected in the liquid phase and in the presence of cobalt catalyst. It calls for operating pressure in the range of 3000 to 4500 psi and temperature of 145 to 200 C.

Activity has been claimed for other catalysts, notably iron and nickel but on the strength of the best available evidence, Oxo catalysis appears to be limited to cobalt.[2] It is further indicated that the active principle is cobalt hydrocarbonyl and that its concentration in the reaction medium is rate-controlling.

Equation 1 shows that two isomeric aldehydes are the primary product of hydroformylation. In addition, there are side reactions which lead, above all, to the formation of other isomers as well as of other types of product, principally acetals and alcohols. The latter are, of course, not objectionable. Their formation in the Oxo stage simply anticipates the intentional production of alcohols in a subsequent hydrogenation step.

$$R-CH=CH_2 + CO + H_2 \begin{cases} \longrightarrow RCHCH_2-CHO \\ \longrightarrow R-C-CH_2 \\ \qquad\quad | \\ \qquad\quad CHO \end{cases} \qquad (1)$$

Beyond that, the product is rendered more complex by the non-uniformity of the olefinic feedstock. To be sure, propylene and butylene can be readily obtained in high purity so that their derived butyraldehydes and amyl alcohols are a relatively simple mixture. On the other hand, the higher olefins, which are employed in commercial Oxo plants are multicomponent sys-

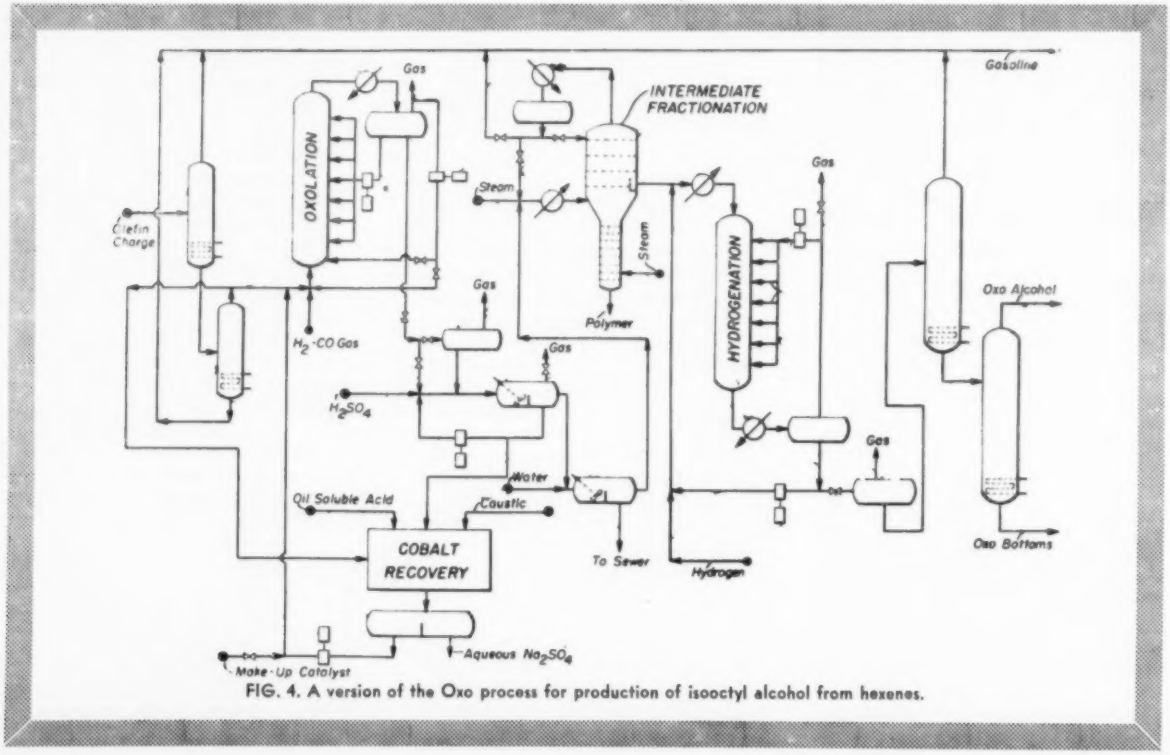

FIG. 4. A version of the Oxo process for production of isooctyl alcohol from hexenes.

tems. Typical compositions of these stocks, which are obtained by the catalytic polymerization of C_3 and C_4 olefins, are shown in Table 2.[3]

With so complex a starting material, it is natural that the plant product will be a multicomponent mixture. Thus, the isooctyl alcohol of the trade has the following typical composition[3]: 20 wt percent 3, 4-dimethyl-1-hexanol, 30 percent 3, 5-dimethyl-1-hexanol, 30 percent 4, 5-dimethyl-1-hexanol, 15 percent 5-methyl-1-heptanol, 5 percent others.

TABLE 2. Composition of Typical Oxo Feeds.

	Volume Percent		
	Heptene	Tri-propylene	Tetra-propylene
$RCH=CH_2$	1	1	2
$RCH=CHR$	12	14	10
$R_2C=CH_2$	10	8	7
$R_2C=CHR$	57	35	26
$R_2C=CR_2$	20	42	55
	100	100	100

Reaction Behavior

Even where a single olefin is the feedstock, two isomeric aldehydes (or alcohols) make up the bulk of the product. The proportion in which these isomers are formed depends on the amount of steric hindrance exerted by the molecular structure of the olefin. Rules governing this behavior may be summarized as:

1. The carbonyl group will add predominantly to the terminal and praeterterminal carbon atoms of a molecule, regardless where the double bond of the feed olefin may have been located. This is strong evidence that the olefin is isomerized under Oxo conditions so that the double bond is shifted to terminal position, and that it is fixed in this structural position by the hydroformylation reaction.

2. Due to steric hindrance, the formyl group will not add to a tertiary carbon atom.

3. In the event a tertiary carbon atom occurs at both ends of the double bond, reaction takes place only after isomerization of the double bond to a more favorable position.

Thus, in conformance with these rules, the alcohols obtained by hydroformylation of propylene followed by hydrogenation, contain 60 percent n-butanol, 40 percent 2 methyl-1-propanol. The product of either 1- or 2-butene is an equimdar mixture of n-pentanol and 2-methyl-1-butanol. Isobutylene conversion leads to 96 percent 3-methyl-1-butanol and 4 percent 2, 2-dimethyl propanol. (These ratios are subject to some variation, influenced by reaction conditions.)

The claim has been made[4] that product composition can be influenced by taking measures which will lead to preponderance of the unwanted isomer in the reaction medium. Such a possibility to guide the reaction is obviously of considerable importance. As we have seen, both iso and n-butylraldehyde are formed from propylene in about the same amounts, yet the market is overwhelmingly more favorable for the normal compound.

Among the methods recommended by Hagemeyer[4] to guide the course of reaction, the most interesting is recycling of the unwanted isomer. Using n-butanol as solvent for the reaction medium, n-butyraldehyde formation is found to increase in direct proportion to the amount of isobutyraldehyde added to the system. Conversely, production of the normal compound declines linearly with increasing n-butyraldehyde added to the reactor. In this fashion, production of the normal compound can be varied from 10 to 90 percent.

Side Reactions

Hydroformylation is accompanied by a number of side reactions, which lead to the formation of such by-products as esters (by the Cannizzaro reaction), ketones (by the condensation of two molecules), and polymerization products. Acetals ($RCH(OR)_2$), formed by the reaction of one mole acetaldehyde with two moles alcohol, are the largest single group of by-products. Their quantity depends on the proportion of aldehydes and alcohols in the system; it passes through a maximum when reduction of aldehydes is 67 percent complete. (This is above the situation normally encountered. In normal 2-stage processing, the alcohol: aldehyde ratio in the primary Oxo product is about 3:1.)

Some water is unavoidably formed in the process; the total quantity amounts to about one weight percent of fresh olefin. Interestingly, paraffin formation due to saturation of the olefin feed is a very minor factor. Such hydrogenation has been reported in only isolated cases; it is probably due to heterogeneous catalysis where cobalt is introduced in solid form. By contrast, the catalysis of the Oxo reaction proper is homogeneous.

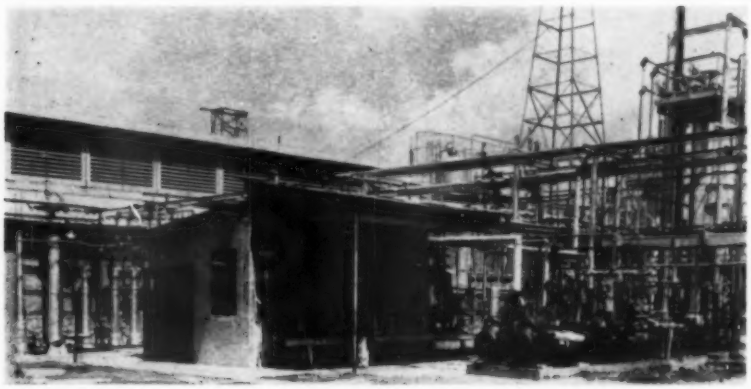

FIG. 5. General view of Esso Standard's Oxo plant at Baton Rouge, Louisiana.
— *Courtesy Esso Standard Oil Company*

Some Thermodynamic Considerations

Considerable work has been carried out on the thermodynamics and kinetics of the Oxo reaction. Main conclusions may be summarized as:

1. The catalysis is homogeneous; cobalt hydrocarbonyl is the effective catalyst.

2. The thermodynamic equilibrium at low temperature is very favorable to hydroformylation; it declines rapidly with increasing temperature. E.g. the equilibrium constant in the Oxoation of ethylene is 6.17×10^{12} at 25 deg C, 3.80×10^{7} at 100 deg C, and 1.41×10^{5} at 150 deg C.[5] In the light of these data, almost complete conversion of ethylene (as well as of propylene) to the corresponding Oxo aldehydes is thermodynamically possible at atmospheric pressure. Nevertheless, the Oxo reaction has never been carried out successfully at pressures significantly below 50 atm. This is almost certainly due to the high partial pressure of carbon monoxide which is required to prevent decomposition of cobalt hydrocarbonyl, the active catalyst.

3. As mentioned, the equilibrium between cobalt carbonyls and carbon monoxide is a key factor in the execution of the process. The required carbon monoxide pressure is a function of temperature as well as of catalyst concentration in the reaction medium. To maintain a practicable concentration of catalyst (0.25 mol percent) would call for only 5 atm at 100 deg C, but requires 180 atm at 200 deg C. For the normal range of Oxo temperatures (somewhat above 150 deg C),

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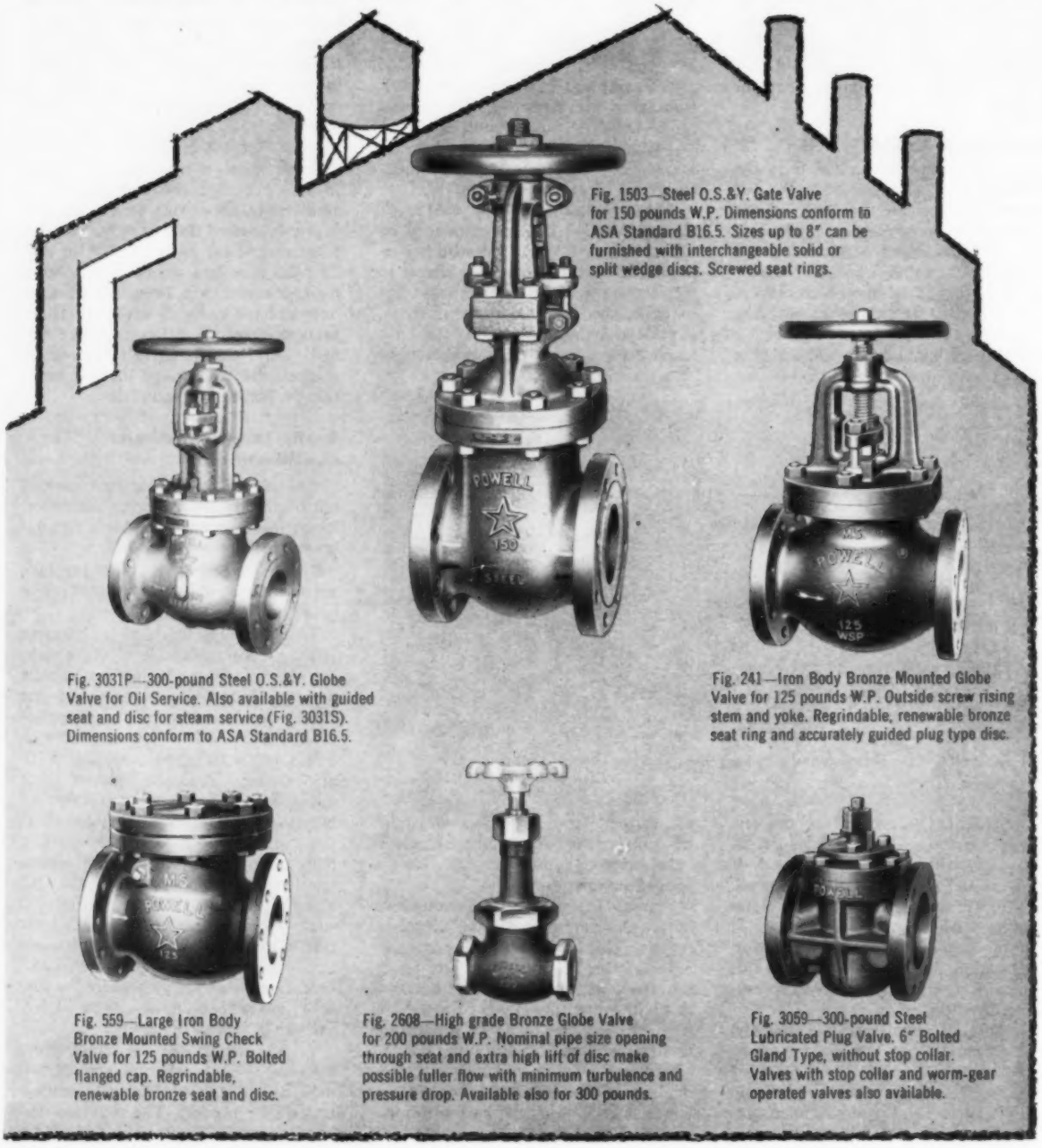

Fig. 1503—Steel O.S.&Y. Gate Valve for 150 pounds W.P. Dimensions conform to ASA Standard B16.5. Sizes up to 8" can be furnished with interchangeable solid or split wedge discs. Screwed seat rings.

Fig. 3031P—300-pound Steel O.S.&Y. Globe Valve for Oil Service. Also available with guided seat and disc for steam service (Fig. 3031S). Dimensions conform to ASA Standard B16.5.

Fig. 241—Iron Body Bronze Mounted Globe Valve for 125 pounds W.P. Outside screw rising stem and yoke. Regrindable, renewable bronze seat ring and accurately guided plug type disc.

Fig. 559—Large Iron Body Bronze Mounted Swing Check Valve for 125 pounds W.P. Bolted flanged cap. Regrindable, renewable bronze seat and disc.

Fig. 2608—High grade Bronze Globe Valve for 200 pounds W.P. Nominal pipe size opening through seat and extra high lift of disc make possible fuller flow with minimum turbulence and pressure drop. Available also for 300 pounds.

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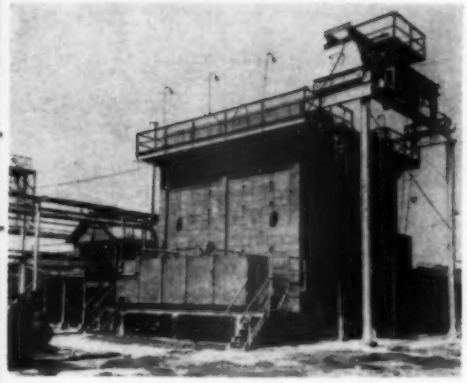

FIG. 6. Esso's Oxo reactors at Baton Rouge are located within a concrete enclosure formerly used for high-pressure hydrogenation. — *Courtesy Esso Standard Oil Company*

minimum carbon monoxide pressure is 35 atm to maintain 0.25 mol percent cobalt carbonyl concentration in solution.

4. First step in the reaction probably involves the reaction with dicobalt octacarbonyl to yield an olefin-carbonyl complex plus carbon monoxide. For a detail expression of the reaction mechanism, the reader is referred to papers by Martin[6] and Wender.[2]

5. The overall reaction is first-order relative to the olefin and zero order relative to the total gas pressure at H_2:CO ratios of unity and total pressures from 100 to 400 atm.[7]

6. Reaction rate is a direct function of cobalt carbonyl concentration; at high concentrations, this relation is approximately linear.[7]

Technology of the Oxo Reaction

Three major independent process variables control performance of the Oxo reaction: Catalyst type and concentration, operating temperature, and contact time. Once these conditions are fixed, the minimum pressure is set by considerations of equilibrium. In addition, there are secondary variables, including CO:H_2 ratio and choice of solvent.

Another variable — recycle — is fixed by considerations of reactor design, control of isomer distribution, and the need to conserve cobalt in usable form.

Finally, there are auxiliary aspects of the Oxo reaction. These include method of removing and recovering or reactivating cobalt from the product stream, methods of converting aldehydes to alcohols, and means for converting by-product acetals to useful products.

The following sections will devote brief attention to these various aspects of the Oxo reaction.

1. Catalyst choice and concentration. We have stated that cobalt hydrocarbonyl is the active catalyst principle. Since this compound is not stable except under high carbon monoxide pressure it is necessary to choose the most efficacious way of introducing cobalt hydrocarbonyl into the system.

A critical aspect of this choice is the rate of cobalt carbonyl formation at the conditions of the Oxo reaction. This makes it essential that the catalyst is supplied in a highly active form. In commercial work carried out in Germany during World War II, it was practice to supply cobalt in the form of a slurry of standard Fischer-Tropsch catalyst (30 percent cobalt, 2 percent thoria, 2 percent magnesia, and 66 percent Kieselguhr). This catalyst is highly active and was readily available at the time (subsequent work indicates that the presence of thoria and magnesia has some disadvantageous effects on the Oxo reaction).

There are some general disadvantages to the use of solid catalysts. They need special handling methods and may lead to some olefin saturation; they are also deactivated by a number of impurities, such as oxygen and sulfur (the latter affects only the hydrogenating ability of the catalyst and thus eliminates the formation of alcohols in the Oxo stage). But, above all, solid catalysts are less highly active than are oil-soluble salts of cobalt, such as naphthenates and oleates.

American technology has therefore leaned toward the use of oil-soluble cobalt salts, which are fed to the reactor, dissolved in the olefin feed. Because of the high cost of these materials, some sort of recovery is indicated. This aspect will be covered in our discussion of decobalting methods.

To measure the activity of these materials in relation to other possible sources of cobalt carbonyl, Mertzweiller[8] employs an oleate comparison factor—a ratio of reaction rate constants: $K = \frac{(k)_{\text{cobalt oleate}}}{(k)_{\text{catalyst}}}$. By this measure, cobalt oleate is 14.2 times more active than cobalt oxide, 29.5 times more active than cobalt metal (presumably in a form other than Fisher-Tropsch catalyst).

There are numerous attempts on record to operate the Oxo reaction with fixed-bed catalyst. An interesting method involves the use of two beds of carrier. The reaction liquor carries cobalt from one bed to another. After the concentration has built up sufficiently in the second bed, process flow is reversed. To date, no fixed bed process has reached commercial stage. Chief difficulty is one of maintaining uniform reaction conditions and proper cobalt balance.

Concentration of cobalt carbonyl in the reactor stream is rate-determining, and we have already seen how this variable is fixed by operating temperature and carbon monoxide pressure.

A minimum practical cobalt carbonyl concentration is 0.25 wt percent on fresh olefin, but commerical concentrations tend to run as high as 0.8 to 1.2 percent and thus call for carbon monoxide pressure in the range of 100 atm at normal operating temperatures.

In the course of reaction, much of the cobalt carbonyl is converted to an insoluble form which remains partly in the reactor and in part is carried out in colloidal form, suspended in the converter effluent. The amount of residual *soluble* catalyst in the aldehydic product decreases as the operating temperature increases. At otherwise comparable conditions in the oxoation of a C_7 olefin fraction, Catterall[9] found that effluent concentration of soluble cobalt decreased from 0.17 to 0.09 percent as the temperature was increased from 160 to 171 deg C.

2. Effect of temperature. We have already noted the unfavorable effect of increased temperature on the equilibrium of the Oxo reaction and on the stability of cobalt carbonyl. Obviously, the rates of both Oxo reaction and carbonyl formation increase with temperature — the former is doubled for every temperature increase of 7 to 8 deg C.

Conversion to useful product passes through a maximum as temperature is increased. Formation of alcohols rises with temperature.

As typical temperature in the commercial oxoation of heptenes, the range 160 to 175 deg C applies. For the conversion of propylene, temperatures of 145 to 160 C are cited.

Limits set on temperature control are not too stringent. An overall range of 10 to 12 C in the process stream is considered permissible. Where an external coolant is employed, a drop of 20 C from heat exchange medium to reaction medium is typical of design practice.

Even so, cooling provisions for Oxo converters are extensive in order to handle the highly exothermic heat of reaction. About 50,000 Btu are evolved per lb-mol olefin converted. In the case of the lower olefins, this value rises up to a maximum of 62,500 Btu per lb-mol for ethylene.[10] Means for providing the needed cooling in Oxo ovens will be discussed below.

3. Contact time. With increasing contact time, conversion of olefin rises to an assymptotic maximum. In a two-stage process, there is little point in extending hold-up beyond the onset of this maximum conversion. It should be

noted, however, that conversion of aldehyde to alcohol continues even after the hydroformylation reaction has been completed. This is a matter which must be taken into account in the development of single-stage alcohol production.

Residence time required to achieve optimum (not necessarily maximum) Oxo conversion depends principally on catalyst concentration and operating temperature, both of which have been discussed above. Typical hourly throughput range in the Oxoation of heptenes is 0.8 to 1.1 vol olefin per volume converter space. With other operating conditions at 175 C, 2600 to 2900 psig and approximately 0.3 wt percent cobalt content, this rate will lead to useful olefin conversion of 75 to 78 percent. Allowing for the space occupied by synthesis gas in the converter, a contact time of 10 to 30 minutes may be counted as typical.

4. Operating pressure. While the Oxo reaction can theoretically proceed at atmospheric pressure, the need to prevent decomposition of cobalt carbonyl calls for partial pressures of carbon monoxide in excess of 40 atm (at 150 C). Since H_2:CO ratio is held near unity, the Oxo reaction is generally run at system pressures in the range of 100 to 250 atm.

Investigations by Natta [7] and coworkers permit the following conclusions:

a. At constant CO-pressure, the Oxo reaction rate is raised by increasing hydrogen pressure.

b. At constant hydrogen pressure, a maximum reaction rate is observed as the partial pressure of CO is increased. This maximum is in the range 8 to 12 atm (at 110 to 120 C). In the range normally employed, a boost in CO pressure reduces reaction rate.

c. At H_2:CO ratio of unity, the effects described above as (a) and (b) offset each other so that *total* pressure has no effect on reaction rate in the range 30 to 400 atm.

5. Ratio of reactants. Effect on reaction rate brought by varying carbon monoxide or hydrogen concentration is described in the preceding consideration of pressure as an operating variable. In general practice, synthesis gas fed to the Oxo converters is composed of hydrogen and carbon monoxide in approximately equal volumes. Higher hydrogen ratios tend to increase the extent of hydrogenation, while a synthesis gas rich in carbon monoxide favors isomerization of the double bond position. In the vicinity of a 1:1 carbon monoxide-to-hydrogen ratio, the exact composition of gas does not appear to be too critical.

In the hydroformylation of gaseous olefins, the hydrocarbon is introduced with the synthesis gas in approximately theoretical ratio. With liquid olefins, synthesis gas is introduced in excess and must be recycled. In this case, the amount of excess gas may vary as widely as 2500 to 15,000 std cu ft per bbl olefin feed. In the hydroformylation of heptenes, a gas rate of about 6500 std cu ft per bbl is typical of commercial practice.

6. Effect of solvents. Where higher olefins are the feedstock, no external solvent is supplied; the hydrocarbon stream itself serves as catalyst carrier and suspension medium. Effect of a number of solvents on reaction rate has been investigated. A definite influence is found to exist but it is not of great significance. Wender[2] reports hydroformylation of cyclohexene at 110 C to be about 50 percent greater in ethyl or methyl alcohol than in saturated hydrocarbons.

For the conversion of light olefins, a suspension medium is universally employed (although vapor-phase conversion has also been carried out in the laboratory [5]). Early work was directed toward the use of hydrocarbons or water in this service. More recently, emphasis has shifted to the use of lower alcohols, e.g. n-butanol as solvent in the hydroformylation of propylene. This approach may be expected to increase acetal formation. It is, however, possible to regenerate alcohol plus aldehyde by heating acetals in the presence of mineral acids (notably sulfuric or phosphoric acids).

7. Reactors for the Oxo process. Problems of reactor design for hydroformylation are of routine character. Allowance must be made for high operating pressure, intimate contact must be provided between gas and liquid phases, and means must be made available for removal of the large amount of heat evolved.

Adiabatic or Isothermal reactor design are feasible. In the former case, both countercurrent and cocurrent flow of the phases have been employed, with the former approach generally preferred, cooling is provided by recycling part of the effluent stream via an external cooler.

Several commercial installations have employed isothermal reactors in which cooling medium is circulated through internally mounted tubes. According to Gwynn,[11] flow velocity in such a reactor must be at least one foot per second and Reynolds number must exceed 11,000 in order to attain the required degree of temperature control and avoid catalyst deposition on the tubes. Maximum permissible tube diameter is five inches, and the ratio of tube length to diameter (= elongation factor) should be above 1440.

8. Decobalting. The product of the Oxo reaction must be freed of dissolved and suspended cobalt, unless it is intended to use this catalyst in the subsequent hydrogenation stage. This removal of cobalt is referred to as "decobalting." As first step, the product of the Oxo reactor is released to atmospheric pressure. Several means are then available to remove residual cobalt.

One commercial method calls for a mild hydrogenation at 150 to 180 C and 100 to 175 psig to convert contained cobalt to the metallic state. In this form, its removal may be effected by filtration or by precipitation on a carrier mounted in the decobalting reactor itself. One difficulty here is that precipitation of cobalt is not uniform throughout the decobalting chamber. The bulk of metal precipitates near the point of entry and causes pluggage (an onstream life of one week has been estimated when the feed to the decobalting chamber contains 0.1 wt percent CO). To overcome this difficulty, one proposal calls for introducing the feed at several points along the length of the decobalting reactor.

More complete cobalt removal is achieved by washing the Oxo product with dilute sulfuric or acetic acid. The resulting aqueous solution contains the cobalt salt in a concentration of 1 to 5 wt percent. Numerous methods have been proposed for the economic recovery of this material in active form. Among them, we might mention treatment with dilute caustic and naphthenic acid to precipitate cobalt naphthenate. Another proposal would recycle dilute cobalt acetate to the Oxo stage and inject it at points where aldehyde concentration; therefore water miscibility is fairly high.

Conversion to Oxo Alcohols

For reasons stated above, the Oxo conversion of higher olefins is universally directed toward the ultimate production of alcohols. This makes it necessary to hydrogenate the aldehydes which are the product of the hydroformylation reaction proper.

Some such reduction (approximately 30 percent) occurs in the Oxo stage itself, but, in present practice, it is necessary to follow the Oxo stage by a hydrogenation step. Here, synthesis gas is replaced by hydrogen.

Solid cobalt catalyst (e.g. on pumice or Kieselguhr) may serve in the hydrogenation reaction, as may also copper chromite or molybdenum sulfide. Usually, pressure is about the same as in the Oxo stage and temperature is higher (approximately 250 C).

A thorough discussion of the hydrogenation step cannot be included in

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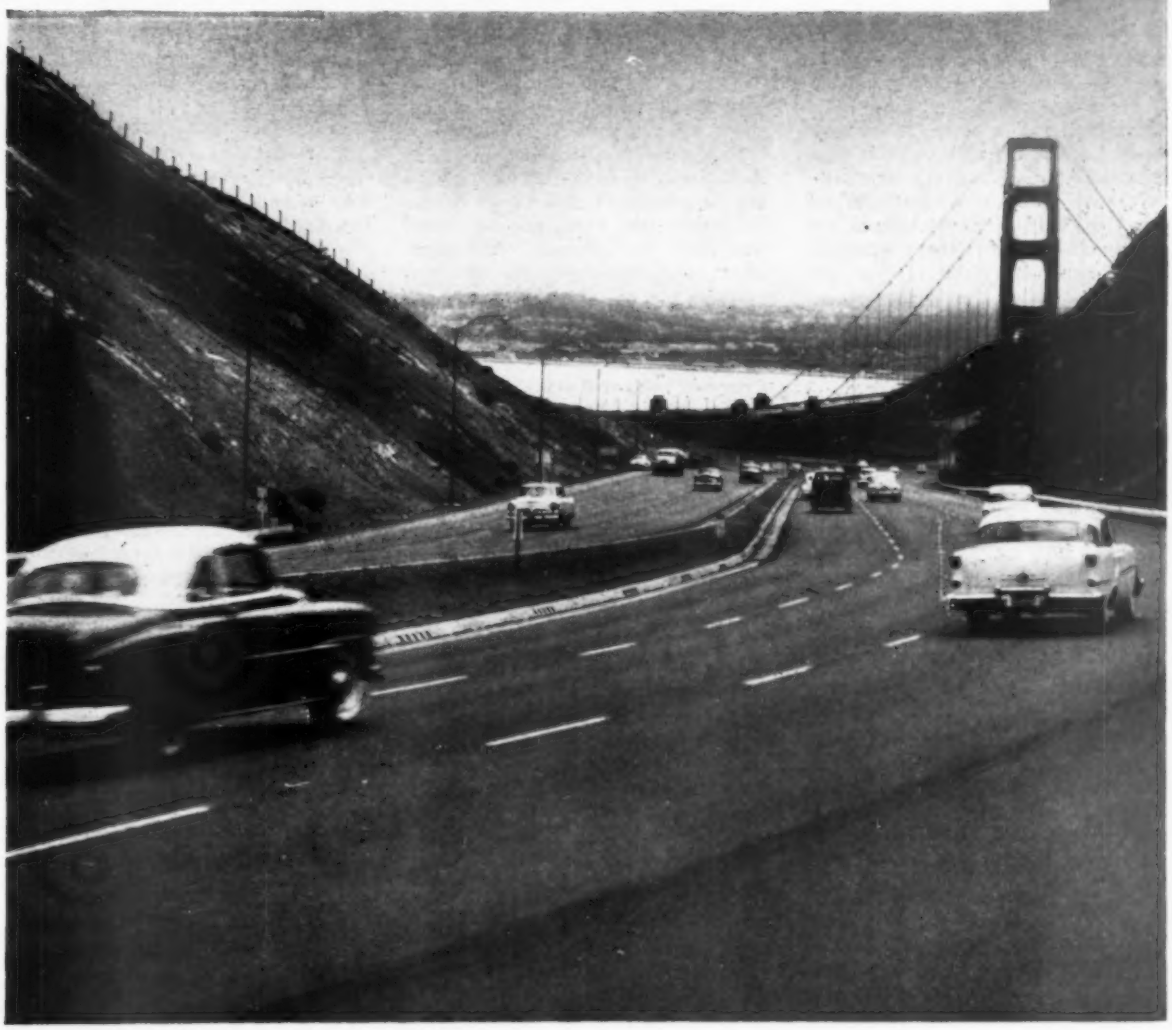

this space; it deserves a separate paper. Mention must, however, be made of work directed toward the simultaneous execution of the Oxo and hydrogenation reactions, i.e. the direct conversion of olefins to the corresponding Oxo alcohols.

To date, no such single-step process has reached commercial stage, but technical — as distinct from economic — feasibility of this approach has been established in recent work.

Berty[12] has shown that, at the conditions of the Oxo reaction, the reduction of higher aldehydes is carried out with greater difficulty than that of the lower members of the series and therefore calls for higher operating temperature. Complete reduction of butyraldehyde is possible at 155 C, in the presence of cobalt carbonyl. Ninety-five percent conversion of cyclohexene to alcohol calls for operation at 200 to 210 C.

Reacting heptenes with carbon monoxide and hydrogen at 200 C and 300 atm, in the presence of dissolved cobalt carbonyl yielded 85 percent alcohols, 5 percent aldehydes and 10 percent high boilers[13].

Complete conversion to the alcohol is quite slow, however. Thus, while aldehyde formation from heptenes reached its maximum after about 15 minutes, nearly 2½ hours were required to obtain approximately the same yield of alcohols by reduction of the initially formed aldehydes. The same reaction conditions were maintained throughout.

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Part 1 of this two-part series, *Products of the Oxo Process and Their Markets*, appeared in the February issue of THE REFINING ENGINEER, page C-16. ★ ★ ★

Keeping Ahead of Waste Water Disposal Problems

EXTENSIVE and costly facilities are needed to treat waste water effluent from refineries. No longer is mere physical separation of entrained oil from water adequate. Desire to be a good community citizen and legislative pressure have made it necessary for refiners to keep their water effluent just about as chemically pure as it was when first entering the plant . . . sometimes even purer.

Effluent treating facilities in use and being constructed at Continental Oil Company's Ponca City, Oklahoma, refinery are indicative of the extent to which refiners will go to avoid contaminating or down-grading public waters. Ponca City Refinery Manager Charles D. Hull says of their effluent treating program "we fully recognize our responsibility in pollution abatement . . . and have kept abreast of the times to the end that the purity of our water effluent has been maintained at a satisfactory level over the past several years."

Effluent Treating at Ponca City

The Conoco refinery uses four to five million gallons of fresh make-up water daily — enough to supply a city of 20-30,000 population. This amounts to about 80 gal of fresh water make-up per barrel of crude when the plant is running at its full-rated capacity of 62,000 bbl per stream day.

Effluent treating facilities include API-type separators for each refining division and the spray ponds, two large final holding basins, neutralizing ponds, a sulfide stripper, and a biological oxidation plant. In addition, experiments are being conducted on "lagooning," a proposed system of ten basins in cascade, each with a one-day retention time. The company has spent about $363,000 during the past few years for new or improved facilities, all designed to improve the quantity and quality of refinery effluent water.

Primary Separators

The refinery is divided into four main process sections: Light Oil; Lubricating Oil; Thermal, and Catalytic Cracking Divisions. In each, the effluent water stream flows through an oil-water separator with API design features before entering the common outfall stream. Also, there are a series of ponds within the refinery which are equipped with oil which enters the ponds through the spray system.

Holding Ponds

Overflow from the spray ponds and the four division separators join in a common outfall stream which then passes through final holding ponds with design features exceeding API specifications. The holding ponds are composed of two large parallel rectangular basins having a capacity of 6.8 million gal — equivalent to three days' holding time. These ponds cost about $150,000 when built in 1954.

The holding ponds serve two purposes: To reclaim any oil that passed through the primary separators and to provide holding time for settling of entrained solids.

Most of the solids are precipitated in the forebays. These accumulated solids are removed weekly by diverting total effluent into one reservoir, thus idling the other. The water and solids in the idle forebay are agitated and the resulting mixture pumped to nearby settling ponds where the water drains back to the reservoirs.

Suspended solids which flow out of the forebays into the main sections of the holding ponds are removed about every two years.

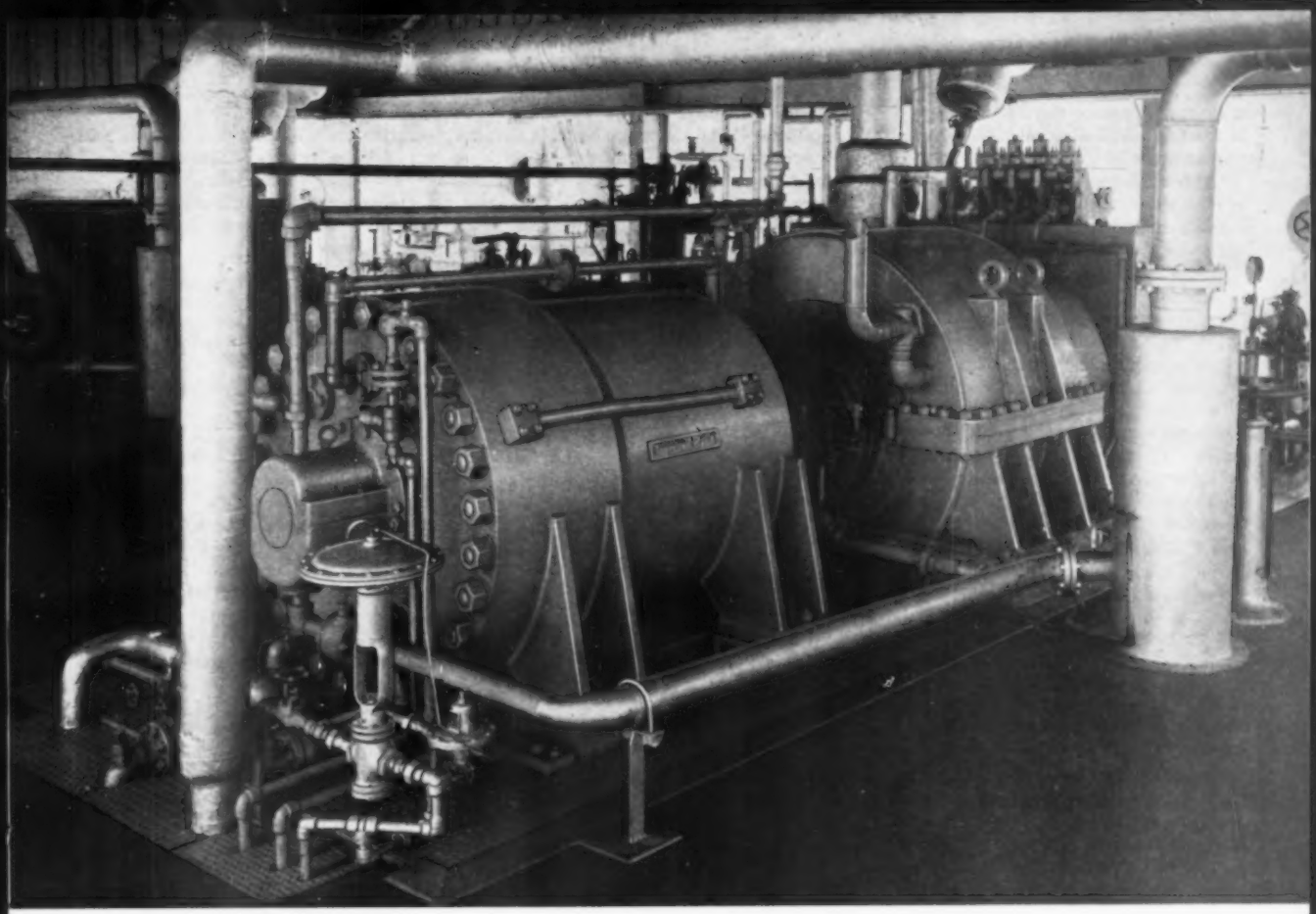
In addition to separating solids and traces of oil from the division and spray pond separators, the main settling ponds provide adequate residence time for aeration and oxidation to take place. Thus the ponds become effective biological treating plants, the same as provided in natural ponds and streams.

Overflow from the main holding ponds flows through a four-mile ditch to the Salt Fork River. For many years the refinery effluent had been divided, with part flowing to the Salt Fork and part to the Arkansas River. This was changed a few years ago, at a cost of $93,000, so that all effluent is discharged to the Salt Fork.

Effluent pH Control

Early water contamination problems included low pH because of extensive use of sulfuric acid for naphtha, distillate, and lubricating oil treating, and alkalinity from use of caustic and lime. The acid problem is largely nonexistent

*Abstracted from a talk "The Refiners' Problem of Waste Water Disposal" given by Ponca City Refinery Manager C. D. Hull at the Second Annual Course in Water Quality Control for Subsurface Injection at the University of Oklahoma, December 11, 1957.



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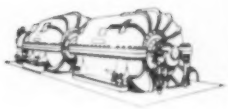

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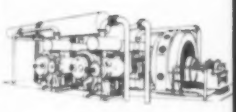

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at Ponca City since the discontinuance of treating lubricating oil with sulfuric acid in favor of solvents.

Other acids used in the refinery, such as muriatic used for equipment cleaning, are included in reasonable limits in the refinery effluent to help neutralize the normally alkaline stream.

"Caustic," Manager Hull points out, "is a difficult problem." Conoco has solved major problems, however, by selling a spent caustic rich in recoverable oils such as cresols and phenols to a chemical company for reclamation. Other strong caustic solutions are put in earthen pits. Certain weak caustic solutions and other alkaline water such as boiler feed water treating solutions and boiler blowdown are neutralized, if necessary, in the holding ponds.

Pilot plant studies made at Ponca City using sulfuric acid to maintain a pH value at or below 8.2 in one bay of the holding ponds indicated that effluent water having a high alkalinity usually has a toxic effect on fish life.

Steam Stripper for Removing Sulfides

Sulfides and phenols, which concentrate in the water phase primarily from cracking operations, are harmful contaminants because of their high chemical oxygen demand (COD). To remove the sulfide from the principal sour water streams, a steam stripper tower costing $45,000 was installed at Ponca City in 1954. Design is for 100 gal per min of feed, and greater than 90 percent of the sulfides in feed water are removed, as shown by these tests:

	Feed water	Effluent	Percent removal
Sulfides-ppm	8960	154	98
Phenols-ppm	866	682	21

Bioxidation of Phenols

Phenol is a very undesirable component in effluent streams. Even in small, non-toxic concentrations chlorination creates a taste and odor problem.

Accordingly, a biological oxidation plant for removal of phenols was recently built at Ponca City at a cost of $75,000. The unit is used primarily for removal of the phenols in the sulfide stripper effluent. The unit uses an activated sludge system to supply bacteria that thrive in water containing phenol and will consume the phenols as well as ammonia and other contaminants such as sulfides.

Excellent results have been obtained, as the table below shows:

	Feed water	Effluent	Percent removal
Sulfides-ppm	221	2	99
Phenols-ppm	737	37	95
Ammonia-ppm	2363	884	63
pH	9.4	8.4	—

Testing Effluent Water

Bio-assay tests are made weekly in the refinery laboratory to determine toxicity of water as it leaves the holding ponds and as it enters the Salt Fork River. These tests have shown that there is material improvement in the water even as it flows the four miles in the ditch connecting the basins with the river. This is attributed to aeration and bacterial action in a flowing stream.

Frequent spot checks are made on individual effluent streams and plant personnel have been instructed to segregate harmful wastes for special handling, if needed. Samples of effluent water from each division are inspected every four hours in the laboratory. And, a daily composite is made of these four-hour samples for a one-week period of analytical testing.

Lagoon Pilot Plant

Conoco is currently studying lagoons — ten ponds in cascade, each with a one-day retention time — as a means of water effluent quality improvement. Purpose is to determine the optimum surface-to-volume ratio.

Using a series of 55-gal drums cut in half and laid lengthwise and another series of whole drums standing upright, the two extremes of shallow and deep ponds have been examined. Some test results show:

	Shallow lagoons (Half drums)		Deep lagoons (Whole drums)	
	Water in	Water out	Water in	Water out
Immediate oxygen demand—ppm	5.2	0.0	6.0	0.0
Chemical oxygen demand—ppm	250	175	275	187
Dissolved oxygen—ppm	0.0	5.5	0.0	2.0
pH	8.3	7.2	8.4	7.4

Conoco researchers say that these results show the shallow lagoons with larger surface areas appear to give more rapid rate of oxidation for residual chemical wastes. But, they point out, the two pilot units are possibly not adequate to show the relative bacterial action of the two systems. For instance, holding time variables also have to be considered.

Manager Hull says that an ideal objective would be a series of lagoons in which fish life could always be maintained — at least in the last lagoon. Hull concludes that "such lagoons should not be regarded as replacement for other treating facilities. Their function should be primarily for final oxygen buildup to provide for bio-oxidation of slowly oxidizable trace wastes and as insurance against surges from accidental spills and mechanical failures." ★ ★ ★

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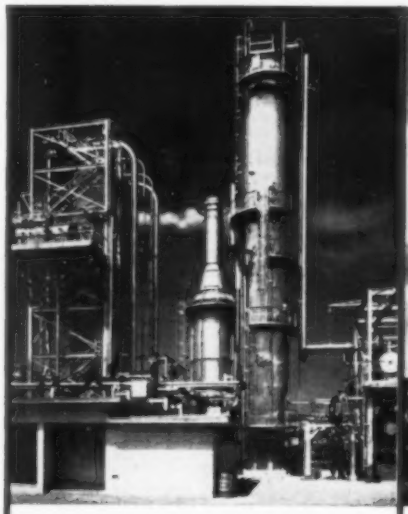

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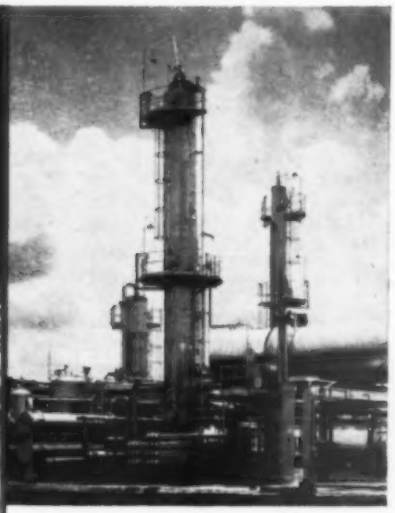

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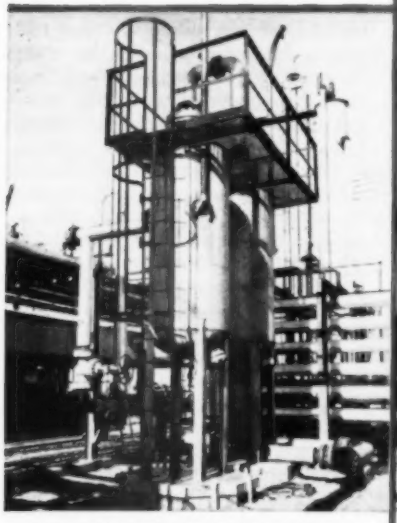

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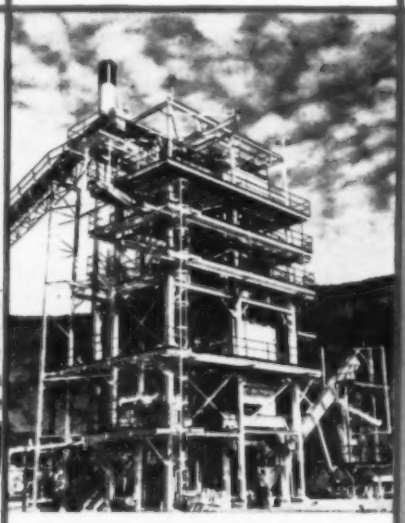

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SELECTION OF FURNACE

Part 2: Factors in Selection — Structural Change, Cost and Fabrication

Thomas M. Krebs
The Babcock & Wilcox Company
Tubular Products Division

CORROSION CONDITIONS are highly important, and often difficult, factors to weigh in the selection of heater tubes. Tubing alloy selection to withstand corrosion environment may be greatly simplified by accurate inspection records of metal loss and by a proper corrosion test program. This program need not be elaborate. In the simplest case it involves exposure of specimens of various analyses (which may be obtained free from manufacturers) to the process conditions with subsequent examination after some appropriate period of test.

Results of such tests must be used with discretion because many factors can affect corrosion rates; however, they do present a very useful point of beginning for analysis of actual alloy needs in terms of the corrosive environment. In the absence of sufficient information, the natural result is under-alloying or over-alloying. Either can be expensive.

A corrosion control program can be carried out to good advantage in the operating refinery where proper testing and experience aid greatly in keeping corrosion in check. Although corrosion problems usually have an individual flavor, and often require specific solutions, the experiences gained in one area or process frequently have some application elsewhere for selecting tubes. Because space limitations prevent detailed analysis of refinery corrosion problems which have been discussed elsewhere,[6] only a few common types have been singled out here.

Oxidation and sulfur corrosion are the most common types of corrosion in petroleum service. The remedy is tried and true and the same for both — use alloys of higher chromium content. The permissible maximum operating temperatures to insure long life in oxidizing furnace atmospheres for common heater tube alloys are shown in Table 1.[7] These temperatures are not based on laboratory data but have been established through years of experience.

Mechanical Aspects of Corrosion

The mechanical aspects of corrosion receive relatively little attention. One facet is oxide notching which results from preferential oxidation at scale breaks formed by mechanical flexing. It is usually due to thermal fluctuations and is, therefore a form of corrosion fatigue. Notching caused by corrosion fatigue allied with thermal fluctuations has also been observed in boiler tubing. Oxide notching may be overcome by adjustments to obtain more uniform temperature distribution to minimize thermal strains or by the use of more oxidation resistant alloys. Notches may in themselves cause failure or they may contribute to failure.

Fig. 4 shows an unusual sample of a Croloy 7 tube from a vacuum unit which failed on hammer test and was thought to be temper brittle. (This was of interest because temper brittleness has not been a problem in wrought heater tubes for many years — although it may occasionally be found in Cr-Mo castings because of segregation.) Subsequent examination indicated the presence of oxide notches from severe longitudinal flexing. Ductility was restored when the notches were removed by grinding.

This example is only one of many observed by the writer in many years of examining tubing after service, illustrating the importance of metallurgical examination. Cause of failure may be quite different than appearances in the field suggest. A knowledge of the cause of any failure is of the utmost importance in selecting tubes for replacement and remedy.

Effect of Charge Stock on Tube Selection

Where corrosion problems are caused by high sulfur in oils, the usual refiner's remedy has been to use the higher chrome alloys, namely Croloys 5, 7, and 9M. Popularity of these steels remains high. In fact, the latter two alloys appear to be finding increasing application for handling high sulfur crudes and stocks. The 9M alloy is particularly favored for handling sour West Coast crudes and derivatives, and for coking applications where it exhibits good carburization resistance in addition to resistance to oxidation and sulfur attack. The 18-8 (Type 304) stainless steel is also very resistant to sulfur corrosion.

Catalytic reforming has caused corrosion problems associated with sulfur compounds that have necessitated a somewhat different approach to tube selection. Here, the difficulty involves corrosion by hot mixtures containing hydrogen sulfide and hydrogen gases. This corrosion problem has been attacked by using corrosion resistant materials or by desulfurizing the charge stock. However, in hydrodesulfurization the corrosion problems may be transferred to some extent from the reformer to the desulfurizer.

Extensive laboratory tests and service experiences have been reported.[8,9] In general, the chrome-moly alloys so useful in "conventional" sulfur corrosion lack resistance to hot, concentrated hydrogen sulfide-hydrogen mixtures. Voluminous, brittle scales formed by such tubing have really been more troublesome from the standpoint of equipment plugging than metal loss.

Maximum resistance is obtained with the 18-8 austenitic stainless steels. However, since the degree of resistance depends on temperature and the hydrogen sulfide concentration, a number of alloy steels are being used for tubing in heaters for catalytic reformer and hydrogen desulfurizer service. These include alloys such as Croloys 2¼, 5, and 9M for the lower hydrogen-sulfide contents, Croloy 12 for intermediate concentrations and the austenitic stainless steels such as 18-8, 18-8CbTa, and 18-8Ti types for the highest concentrations of hydrogen sulfide.

Aluminum-coated, chromium-moly steel tubes also are being used in catalytic reformer heaters. The aluminum confers resistance to sulfide corrosion — the chrome-moly alloy confers elevated temperature strength and resistance to hydrogen attack.

Certain questions must be considered before selecting coated tubing because corrosion can occur at breaks or gaps in the coating. Further, it is frequently necessary to clean reformer equipment to remove coke, polymer or scale deposits. This may require steam-air cleaning and/or acidizing, which

TUBES For Refinery and Petrochemical Service

FIG. 4. Oxide notching (note scale cracks) in Croloy 7 heater tube from a vacuum pipestill. The adjoining portion was fractured in a hammer test.

raises questions concerning their possible effects on the thin aluminum layer. Acidizing operations on any tubing should be conducted by experienced personnel who are well supervised. Care must be taken to choose the kind and concentration of acids and inhibitors carefully to avoid damage to the equipment, including accessories such as thermowells.

Occasional difficulties with stainless steel tubes in reformer service have been reported. In one of the earliest stainless reformer tube installations, intergranular cracking of the stress-corrosion type occurred adjacent to welds in Type 304 tubes (Fig. 5). Cracking seemingly initiated under the influence of residual welding stresses acting at grain boundaries which had been sensitized and then corroded by polythionic acids formed from sulfides and condensate during down-time.

Several methods are being used to combat the possibility of this type of attack in stainless equipment in other reformers. These include: (1) Use of stabilized stainless steel. Chemically stabilized Types 347 and 321 are being used. (2) Use of alkaline sodium carbonate solution to neutralize any acid formed during down-time as reported by Hildebrand.[10]

These same remedies can also be used in any plant service where intergranular corrosion of unstabilized austenitic stainless steels can occur during shut-down. In refinery situations this happens most readily when temperatures are in the lower portion of the 800 to 1600 F range in which intergranular carbide precipitation occurs. At temperatures of 800 to 1000 F diffusion rates are so low that an intergranular chromium deficiency (sensitized condition) is not readily healed. A 1625 F stress relief and stabilizing heat treatment after welding cleared up the trouble in the Type 304 tubing mentioned above. Stress relieving of austenitic stainless as a preventative against stress corrosion cracking including the transgranular type from chlorides, presents certain problems and should only be performed after consultation with qualified metallurgical personnel.

Structural Changes in Service

Structural changes occurring in service sometimes need to be considered in tube selection. Structural changes in steel can be caused by chemical action, e.g. carburization, decarburization, hydrogen attack, or nitriding. They may also result from solid state physical reactions such as precipitation of carbide or sigma phase, graphitization, carbide agglomeration or other processes.

Correct evaluation of significance of these phenomena is a problem that may arise. Sigma phase, for example, is usually discussed at length in any treatise on austenitic stainless steel and great stress is laid on its embrittling character. On the practical side, sigma embrittlement is rarely the cause of tube failures in heater or elevated temperature service. If sigma precipitation is severe some care must be used during shut-down.

The 25 Cr-20 Ni grade has given excellent performance in heaters for gas cracking at temperatures at which sigma forms. Even Croloy 27, a straight chromium grade which is highly susceptible to sigma phase and 885 F embrittlement was used successfully for 12 years in butane preheaters and other high-temperature equipment in butadiene production. (The latter was an extreme case because poor weldability and low strength in addition to embrittling tendencies make this alloy and ferritic 18, 20 or 22 percent chromium steels containing no nickel poor choices for heater tubes.) Naturally, maintenance problems may exist in extreme cases of embrittlement by sigma but experience shows these are not insurmountable.

Graphitization, another much discussed metallurgical phenomena, has never been a problem with heater tubes. Sigma formation in stainless steels and carbide coalescence in carbon and alloy steels leads to reduction of strength in time. However, these changes also occur during testing and are reflected in the test data. This fact constitutes an important reason for performing long time creep or creep-rupture tests.

Carburization is a common form of structural change in hydrocarbon heater service. In most heater services the carburization which occurs in service is not severe barring temperature excesses in operation or frequent steam-air decoking.

In refinery applications carburization is more frequently considered with respect to tube retirement than selection. A carburized condition often raises questions regarding the suitability of the tube for further service. Each case should be considered on its merits. Normally ductility of the tube at its operating temperature is unaffected

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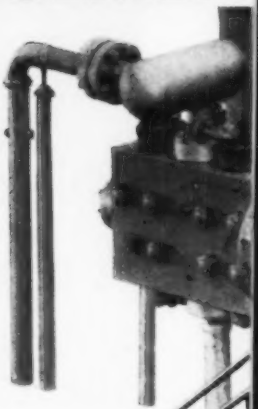

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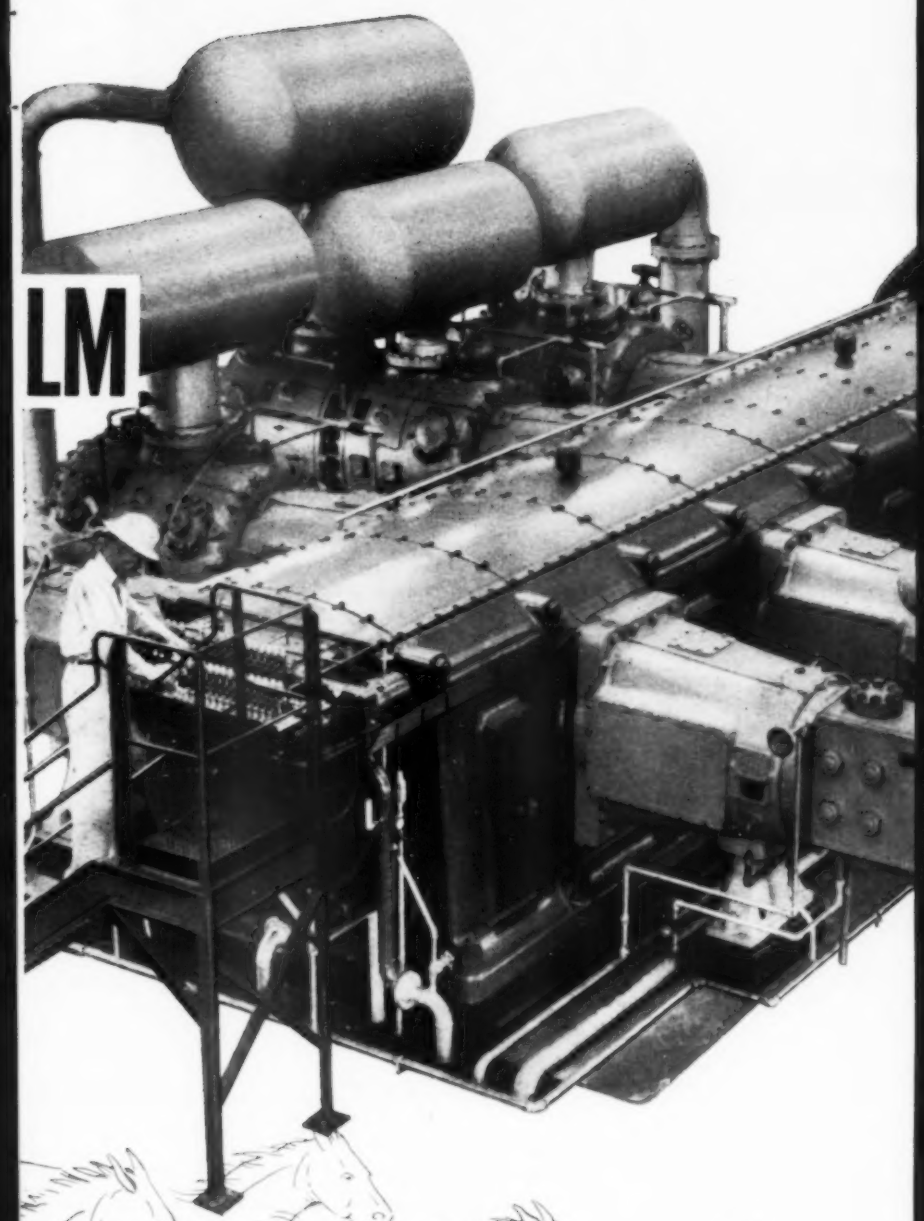

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FIG. 5. Illustration of intergranular stress corrosion cracking adjacent to weld in Type 304 after down-time corrosion by sulfur acids in a catalytic reformer heater.

with carburization to 10 to 15 percent of the wall. Elevated temperature strength is not significantly affected by small amounts of surface carburization or decarburization. This was proved by stress rupture tests on specimens of .20 percent carbon steel. Some of these had been carburized and some decarburized by laboratory means and the results compared with control specimens.

Thermal history is important in carburized chrome-moly steels. Carburized cases resulting from service may be well tempered and have some ductility. Carburization and/or tube hardening which might result from a fire, extreme thermal upset or thermal decoking can cause cracking or may require added care in handling during maintenance. The effects can only be assessed by proper inspection or metallurgical examination. Carburization reduces the effective chromium in solution in the chrome-moly or stainless steels and thus can decrease corrosion resistance.

Carburization is a factor in the selection of tubes for petrochemical heaters, particularly for gas cracking service. For instance, in ethylene production the presence of hydrocarbon gas and steam at metal temperatures of 1600 to 1800 F can cause severe carburization. In one case, Type 304 proved unsatisfactory for this service when failures occurred by longitudinal and transverse cracking. Unusual erosion was also observed at return bends.

A change to Type 310 stainless solved the problem including the erosion. It may be that the Type 304 readily carburized and that hard particles spalled from the case were swept along in the stream to cause erosion. Another possible mechanism is grain loosening caused by alternate carburization and oxidation due to fluctuating process conditions.

Tube steels with increasing alloy content are used to improve carburization resistance. Croloy 25-20 is popular for gas reforming and cracking operations. New melting procedures now make Croloy 25-12 available with an austenitic structure in all heater tube sizes. Service experience on Croloys 25-12 and 18-8Si is less extensive; however, satisfactory results with several heaters using 18-8Si in gas cracking have been reported.

Decarburization is not commonly a problem for properly designed tubing. The removal of surface carbon may result from excessively oxidizing conditions. Since carbides exert an inhibiting action on grain growth, decarburization can lead to grain growth with associated notch sensitivity and susceptibility to fatigue; however, it does not seem to affect hot strength greatly.

Hydrogen attack is a special case of decarburization caused by the reduction of iron carbide by hydrogen. Cracking may occur from pressure of methane from the reduction acting at voids or sub-microscopic crevices in the metal. Hydrogen services are increasing because of catalytic reforming and hydrodesulfurization operations. The chrome-moly or chromium-nickel alloys show greatly increased resistance to hydrogen by comparison with carbon steel because their chromium and molybdenum carbides resist reduction by hydrogen. G. A. Nelson's chart (Shell Development Company) is used in the selection of alloys for the many refinery and petrochemical plant environments involving hydrogen.[11]

Cost Considerations

Tube cost is an important but rarely over-riding factor in the selection of heater tubes. Tubing prices are influenced by many factors such as length, quantities and specifications. Consequently, the price for each job must be determined on the basis of the actual tube requirements. However, in order to provide engineers with some "feel" for tubing costs as a guide to preliminary estimation, relative cost ratios for the common heater tube steels are shown in Table 1 of the first part of this series.[7]

Specific conditions have been used in making the relative cost calculation. In this case a tube size of 5.563-in. OD by .375-in. minimum wall by 35 ft cut lengths was used. Further, the figures are based on furnishing hot finished tubing on all grades except stainless in 20-ton lots, of one size, of one analysis, one grade, to one specification, ordered for manufacture and shipment at one time, to one consignee, at one destination. The stainless ratios have a similar base except they use cold finished tubing in 25-ton lots. In the calculations relative cost of carbon steel

(Continued on Page C-44)

The Author

Thomas M. Krebs is metallurgist supervisor, customer service with The Babcock & Wilcox Company, tubular products division, Beaver Falls, Pennsylvania. Since graduating from Pennsylvania State University in 1949 with a BS degree in metallurgy, he has been employed with B & W in various metallurgical activities. These have led to diversified experience in research, development and application of alloy, stainless steel and specialty tubular products for use in elevated temperature or corrosive services. Krebs is a member of the Refinery Corrosion Committee of The National Association of Corrosion Engineers, the American Petroleum Institute and the American Society for Metals. He is the author of several technical papers dealing with application of carbon, alloy, stainless steels, and titanium tubing.

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Refining Personals

Joseph C. Weaver Jr., has been named to the position of associate director of the research and development department of American Oil Company. Weaver was formerly technical director of the Amoco Chemicals Corporation plant at Brownsville, Texas, which was recently closed.

Dr. Walter C. Bradbury has recently joined the staff of the Cities Service Research and Development Company, product development laboratory at Cranbury, New Jersey, as a section head in the analytical division. Dr. Bradbury had previously been associated with the Celanese Corporation, Dow Chemical Company and the Upjohn Company.

Appointment of two men to key positions in Continental Oil Company's manufacturing department has been announced. **J. P. Markey,** Wichita Falls, Texas, appointed assistant superintendent of Conoco's Lake Charles refinery. He formerly was superintendent at Wichita Falls. **M. H. Clark,** Lake Charles, appointed superintendent at Wichita Falls, succeeding Markey. He formerly was assistant superintendent at Lake Charles.

Dr. W. Mayo Smith has been appointed director of research for the Escambia Chemical Corporation. Dr. Smith has served as assistant director of research in charge of polymerization and plastics research and development since April 1956.

James S. Clarke, Cranford, New Jersey, and **Harry F. Moore,** Mountainside, New Jersey, have been appointed senior engineering associates by the executive committee of Esso Research and Engineering Company. Esso Research is the central scientific affiliate of Standard Oil Company (New Jersey).

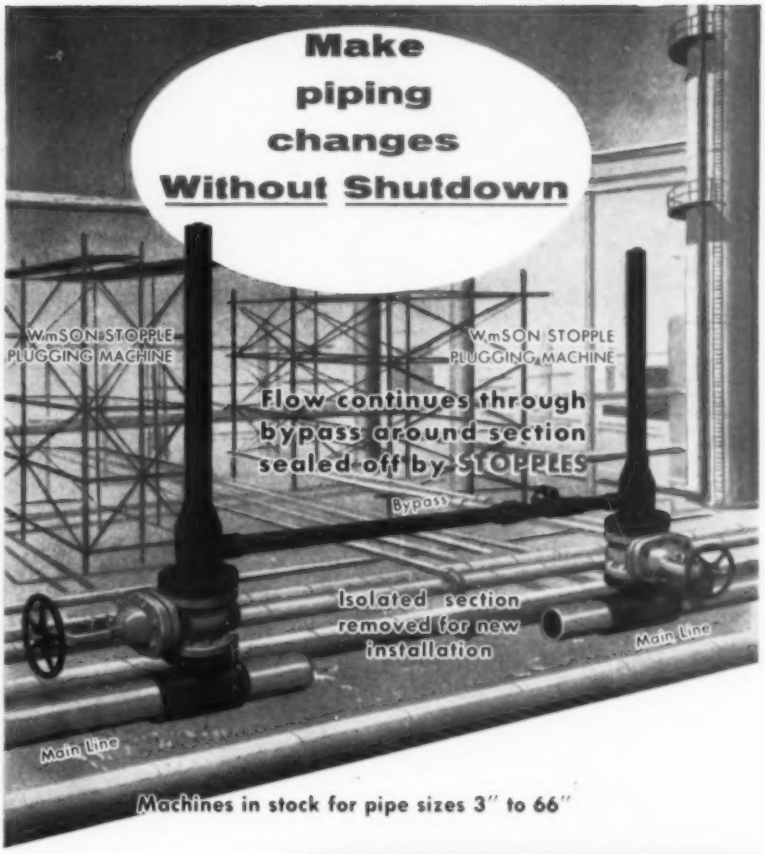
Robert P. Cahn, Elizabeth, New Jersey, has been named an engineering associate in the planning engineering division of Esso Research.

E. Kenneth Burger, a chemical market research expert with the Esso Standard Oil Company, has announced his retirement from the company. He has been manager of the market analysis division of the chemical products department for the past 12 years. He will be retained as a consultant.

C. T. Jones has been promoted to technical specialist in technical service division at Humble Oil & Refining Company's Baytown, Texas, refinery. He is specializing in economic analyses of refinery operations.

E. W. Kilgren, chief plant engineer for the production department, Pan American Petroleum Corporation, Tulsa, Oklahoma, has been appointed vice chairman of the Technical Committee of the Natural Gasoline Association of America.

Edgar I. Crowley and **John R. Weinert** have joined the research and development department of Pittsburgh Coke & Chemical Company. Crowley joins the department's engineering development section as a senior chemical engineer; while Weinert will be a senior chemist in the R & D Laboratory's protective coatings section. Prior to joining Pittsburgh Coke, Crowley was a process development engineer with Davison Chemical Company, and Gulf Research and Development Company. Weinert served as research chemist with Stoner-Mudge Company, and development chemist with Sterling Varnish Company.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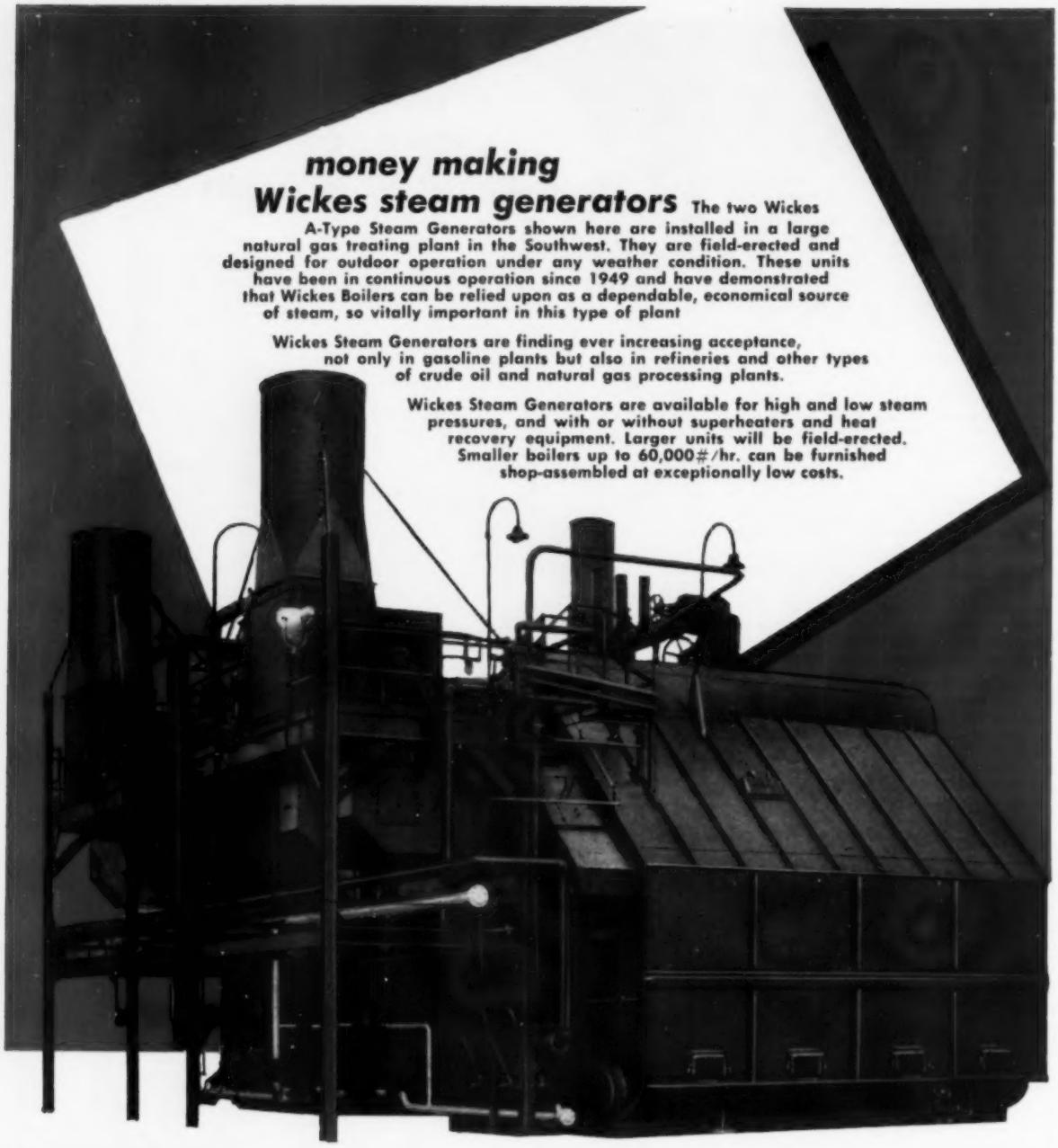

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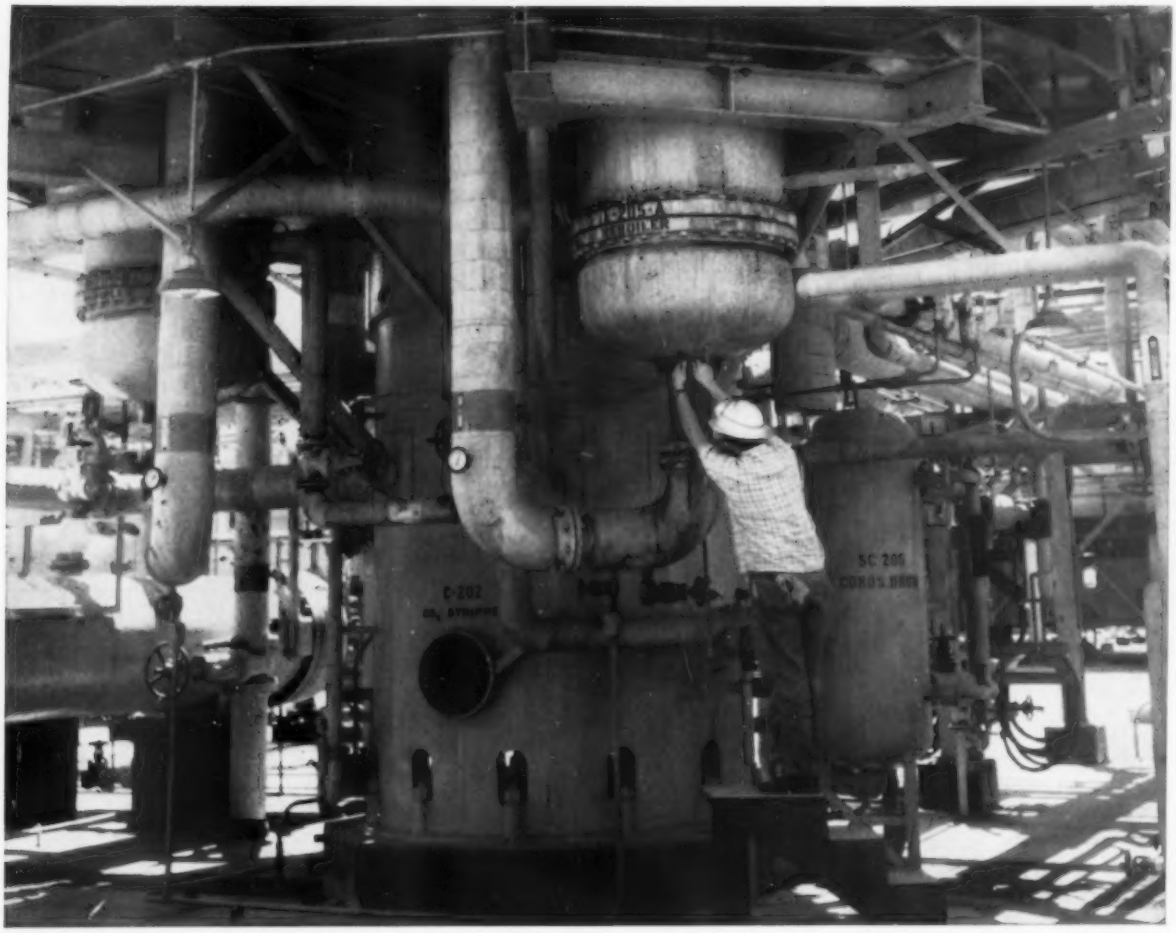

Monel-protected . . . Reboilers on this column used for stripping CO_2 from monoethanolamine solutions at a Shell Chemical anhydrous ammonia plant contain Monel alloy tubes. Tubes have shown no significant corrosion in two years.

Little to do but turn the valves when MEA reboilers have Monel bundles

Shell Chemical checks CO_2 corrosion . . . descales only once in two years

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Used to spend a good deal of time with the two reboilers on this column which strips CO_2 from "fat" monoethanolamine solutions. First he would dismantle one. Descale. Hook up again. Before long it was the other's turn. Every three to six months new tubes had to go in.

But that all stopped in 1954

Shell Chemical put in Monel* nickel-copper alloy tube bundles.

Since then, the reboilers have been descaled but once. What's more, deposits appear to contain no corrosion products . . . just stream precipitates. Tubes look like new . . . have never been replaced.

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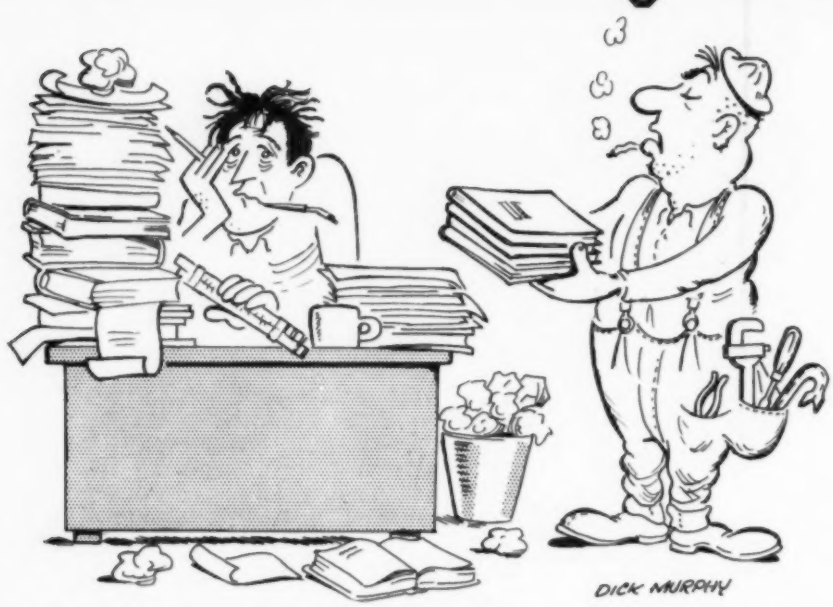

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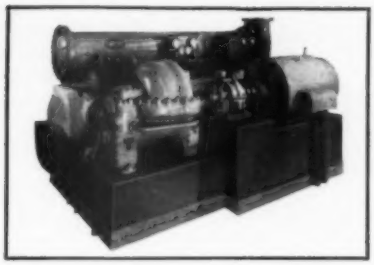

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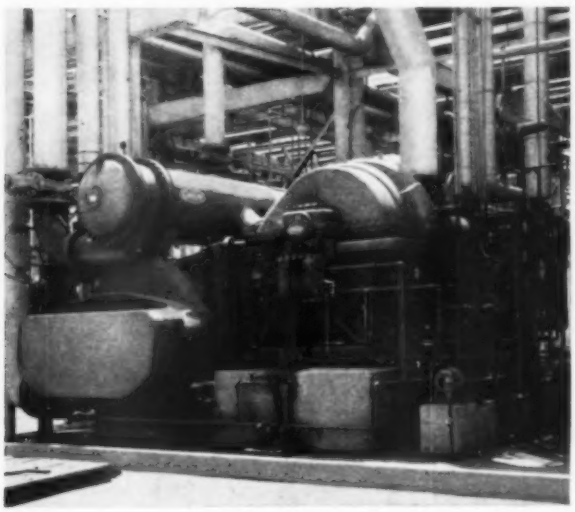

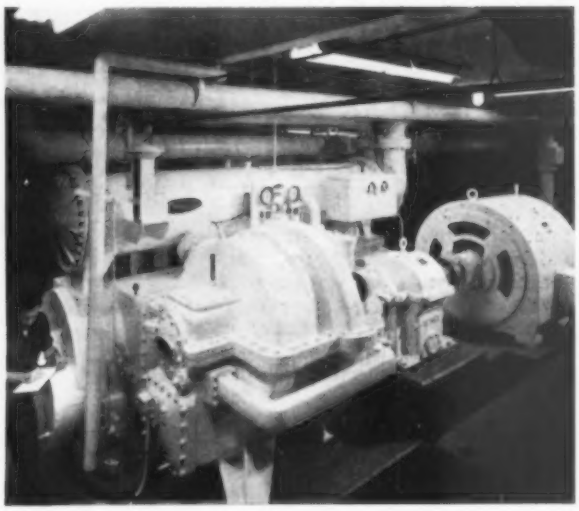

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was considered as 1.00. It may be seen that the alloy content is only a rough guide to the relative cost ratios. The reason for this is that a number of other factors enter into tube prices including method of finishing (hot or cold), manufacturing difficulty, etc.

Cost ratios permit certain interesting comparisons — particularly in the stainless steels. Of the stabilized steels Type 321 is seen to be 11 percent less expensive than Type 347. Type 347 (18-8CbTa) is 11 percent cheaper than Type 348 (18-8Cb). The latter grade is now favored only for certain atomic energy work because of its restricted tantalum content (.10 percent max.). It has been supplanted for all practical purposes by Type 347 in which the carbide is stabilized by columbium-tantalum. The ratio of columbium present is normally about four times the tantalum content. Croloy 18-8Si (Type 302-B modified) is seen to be on a price par with Type 304 and much less expensive than Types 309 and 310. In view of its low cost, resistance to oxidation up to 1700 F, and performance, Croloy 18-8Si is well worth consideration for high-temperature applications including gas cracking. Here again, Type 309 is much less expensive than 310.

It should not be necessary to point out that the first cost for tubing should not be the deciding factor in selection unless other things are equal. What may appear to be a significant saving in first cost to be gained by using a less serviceable alloy can be quickly nullified by increased down-time and maintenance costs. These usually mount at a faster rate than tube price ratios.

Fabrication

Fortunately, today, tube selection is seldom influenced by fabrication considerations for the more common furnace tube alloys. (This is not generally true for certain straight chromium stainless steels mentioned previously.) Serious problems in bending and welding the chrome-moly steels have largely disappeared. Knowledge gained from research activities has permitted development of proper techniques which have been broadcast widely to fabricators and operators. Cracking from bending of the chrome-moly steels in the 1450 to 1800 F hot short range was once common — it is now rare. Excellent progress has been made in the welding of the chrome-moly steels. These are now joined with a low incidence of trouble using arc welding with 300 to 600 F preheat and low hydrogen (Type 15 coating) electrodes. Welds deposited from low carbon electrodes containing up to 5 percent chromium develop low hardness and good as welded ductility.

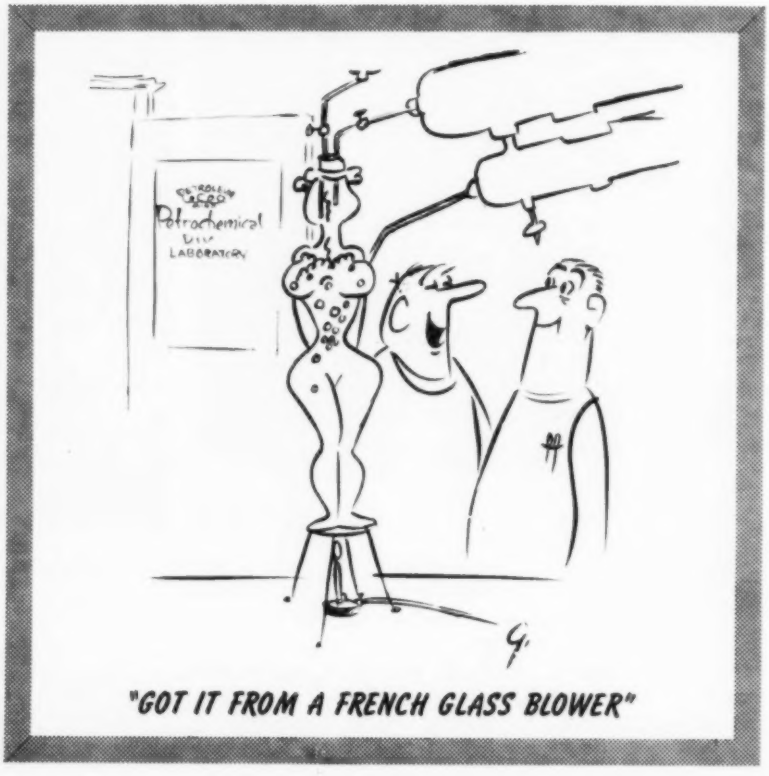
Weldability questions in connection with the stabilized austenitic steels, particularly Type 347, have perhaps influenced selection for certain service. This is doubtless due to numerous technical articles over the past several years dealing with welding problems encountered with heavy wall-steam piping. Here, the heavy wall thickness leads to severe restraint conditions which are not met in welding of heater tubes. Very large quantities of Type 321 and Type 347 have been welded satisfactorily and used in steam superheaters and other elevated temperature services. A 19-9CbTa electrode depositing weld metal with 5 to 7 percent ferrite gives best protection against microfissuring difficulties. The incidence of this intergranular form of weld cracking has also been greatly decreased in 25-20 welds by careful control of chemistry in the direction of controlled silicon and carbon contents.

Steadily increasing size of heaters has brought a demand for larger and longer tubes. Recently an order was filled for Type 304 tubes 8⅝ in. by 0.375 in. approximately 80 ft long for a catalytic reformer. Even longer lengths are under consideration. These long lengths are commonly obtained by welding two or even three shorter lengths by means of flash or manual arc welding. In manual arc welding, modern techniques are used for making the root pass. These utilize inert gas shielded arc fusion which eliminates "backing ring" weld notches or crevices in which coke can build up. The root pass is followed by flux-shielded metal arc filler passes.

Conclusion

In these articles the primary considerations in the selection of heater tubes have been described. Preliminary studies can be performed with the information presented. In coping with the problems encountered in specific heater tube selection situations, knowledge of metallurgical and corrosion data is essential. The required information can be measured or obtained from manufacturers. However, experience and especially, sound engineering judgment, are equally important to the engineer in furnace tube selection.

6. T. M. Krebs, "The Corrosion of Ferrous-Metal Tubing in Refinery Service," *Oil & Gas Jour.* (9 parts) January to May 1957.
7. T. M. Krebs, "Selection of Furnace Tubing; Part I — Mechanical Considerations, Types of Tubing Used," *The Refining Engineer*, February 1958, p. C-54.
8. G. Sorell and W. B. Hoyt, "Collection and Correlation of High Temperature Hydrogen Sulfide Corrosion Data," *Corrosion* 12 (5) p. 213-234 (1956).
9. E. B. Backensto, "How 31 Companies are Fighting Corrosion in Cat Reforming," *Oil & Gas Jour.*, 55, No. 20, p. 180-190 (1957).
10. E. L. Hildebrand, "Intergranular Corrosion of 18-8 Cr-Ni Steel as a Result of Hydrolysis of Iron Sulfide Scale," *Corrosion*, 12, No. 10, 75-6 (1956).
11. Corrosion Data Survey, 1954 Edition, Shell Development Company, (Compiled by G. A. Nelson). ★ ★ ★



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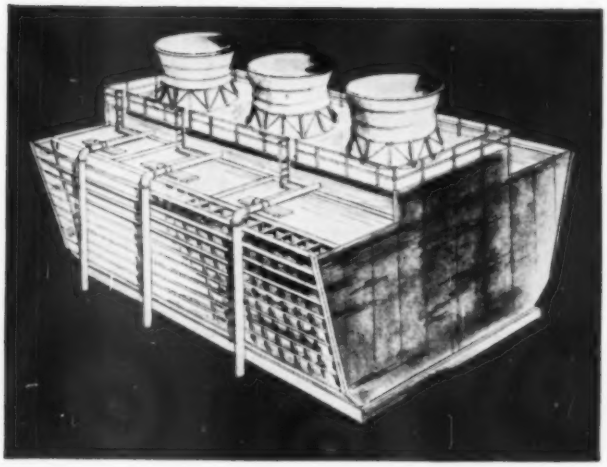

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Charles E. Gibson, *Assistant Editor*

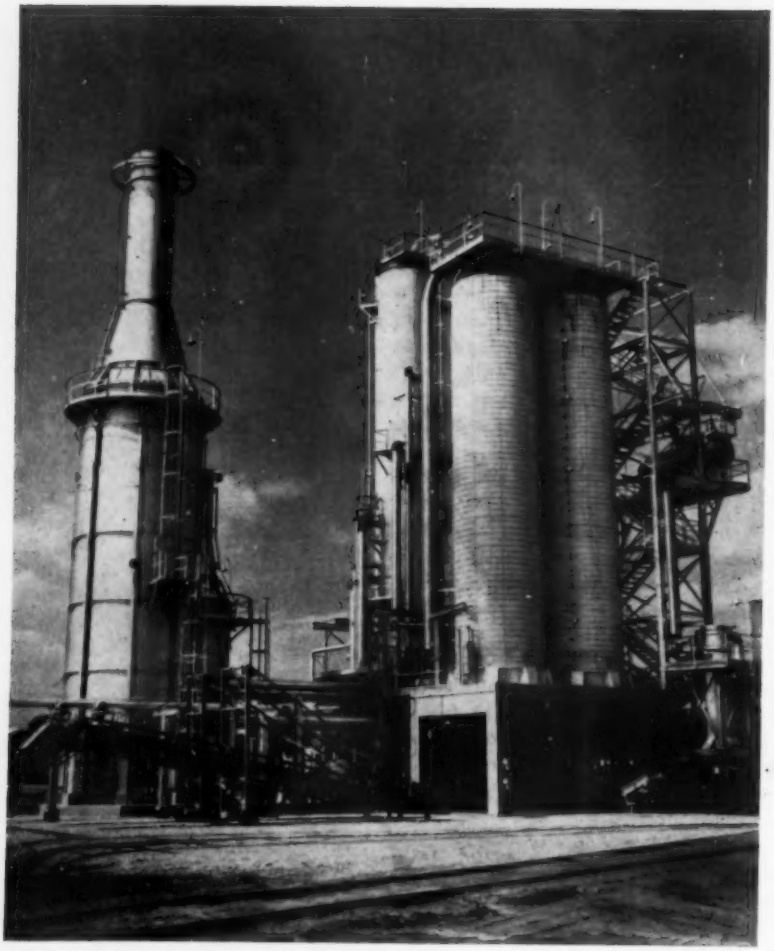


FIG. 1. The fractionator (background) processes both feed and products at La Gloria's, Tyler, Texas, low pressure coking unit.

PRIMARY purpose for coking of crude bottoms is to produce maximum coker gas oil for catalytic cracking and minimum coke and coker gasoline. Low coker operating pressures favor desirable yield structure, as refiners have known for some time. Yet, it was not until 1954 that the first low pressure coking unit was installed.

More than three years' successful operations at La Gloria Oil & Gas Corporation's Tyler, Texas, refinery have demonstrated the feasibility of the low pressure process, and it's expected that most new installations will be of a low pressure design.* Another unique feature of the Tyler unit is the use of a vertical tube heater for the coking furnace. This was made possible by use of a special steam injection scheme.

Typical yields experienced from topped crudes at the 25,000 bbl crude per day Tyler refinery, give this yield profile for 26.6 API decarbonizer feed:

Gas	82.5 cu ft/bbl Charge
Gasoline	5.6 Vol % on Charge
Gas Oil	88.6 Vol % on Charge
Coke	8.9 Tons/1000 bbl Charge

Data on feed and products are given in Table 1. Yields in the fluid catalytic cracking unit are difficult to determine because the coker gas oil is, of course, cracked together with varying quantities of light virgin gas oil. Pilot plant yields on a once-through basis have, however, been determined and given in Table 2.

Process Operations

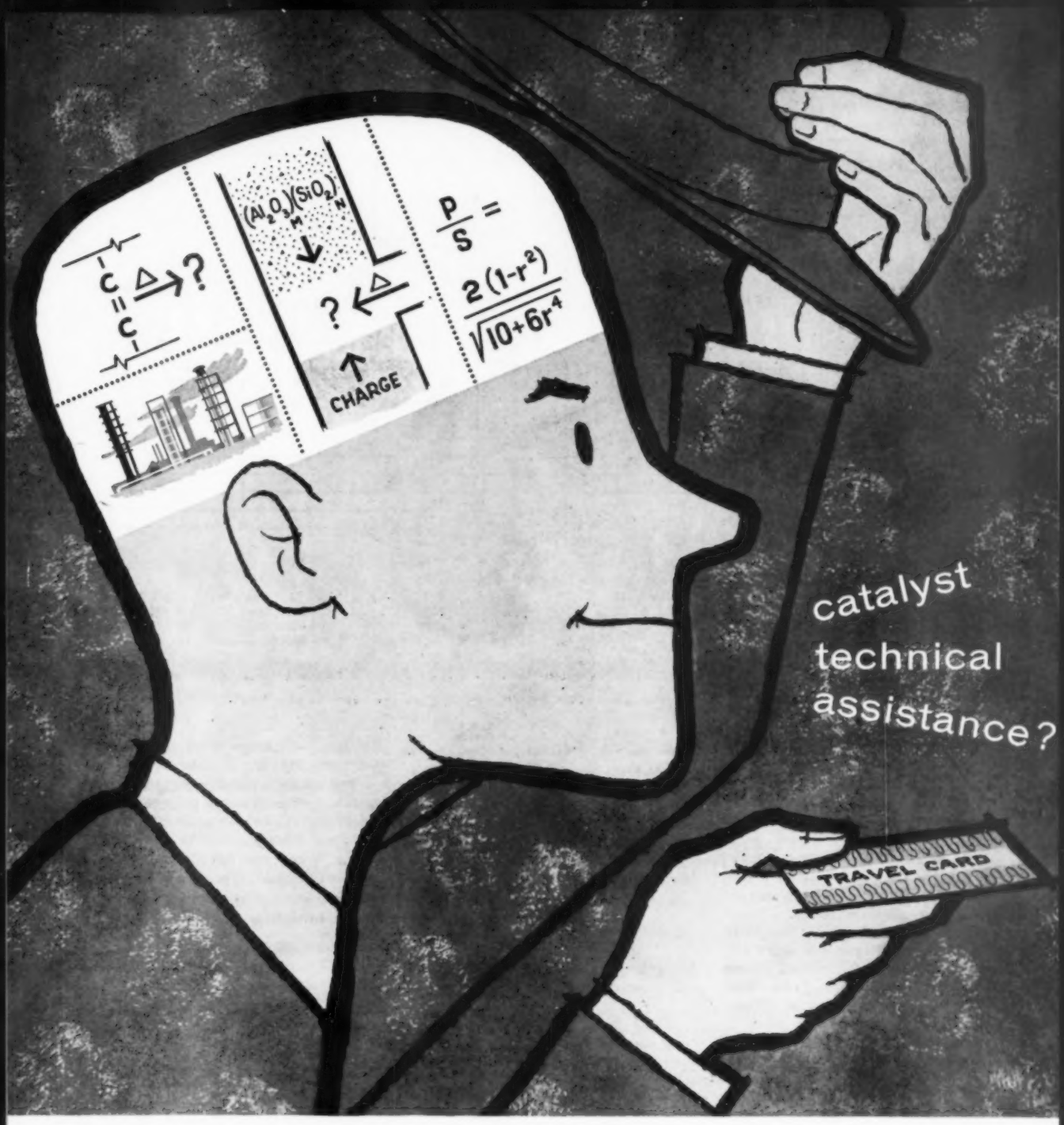
Low pressure decarbonizing, a development by the Chemical Plants Division of Blaw-Knox Company, is so-called because it is used primarily to prepare catalytic cracker feed.

Basic components of the unit are a preheater for reduced crude, a combination feed-products fractionator, the coking furnace, and two coke drums.

Normally, handling 8000-8300 bbl per day of reduced crude, the unit can handle under maximum conditions 9000 bbl daily of topped crude, sending a total of 2200 bbl per day of 12.5 API bottoms to the coking furnace. The balance is removed as gas oil.

Referring to the flow plan (Fig. 1), reduced crude from the crude units is preheated from 500 to 850 F and charged to the combination fractionator. Additional heat for deep flash is provided by coker product; fractiona-

*Tyler Refinery was owned by McMurrey Refining Company when the decarbonizing unit was constructed and put into initial operation.



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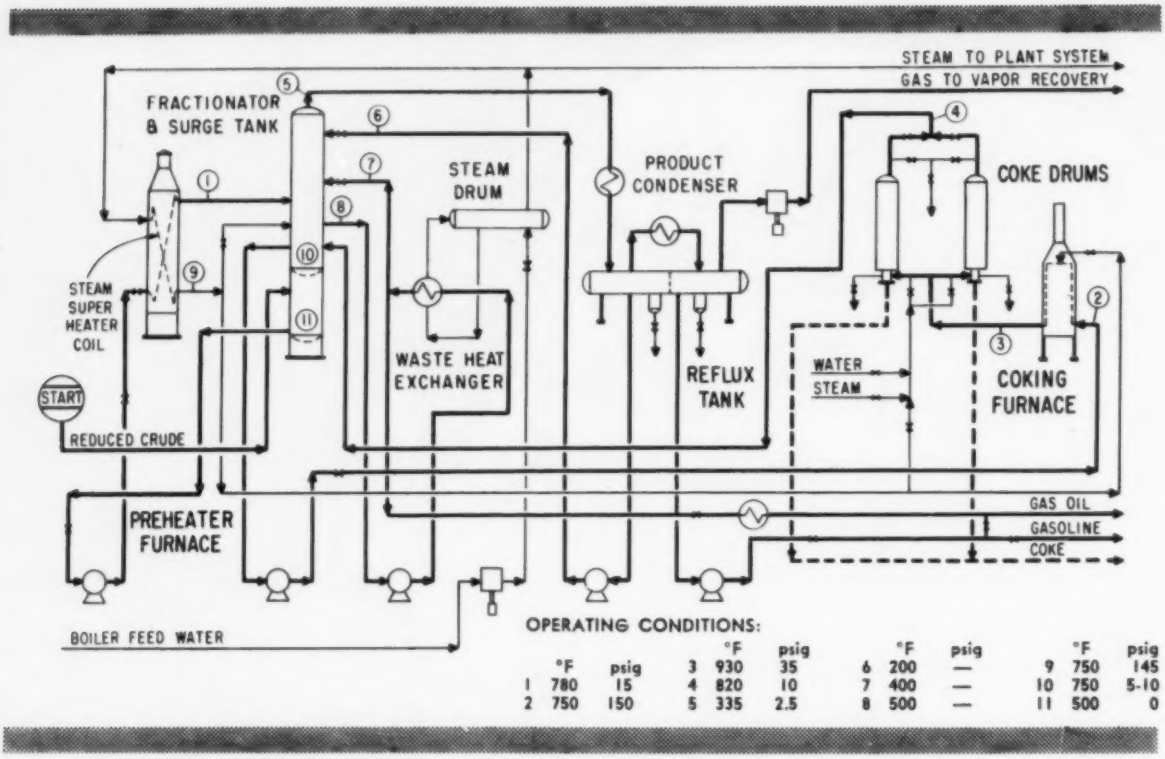

	°F	psig		°F	psig		°F	psig		°F	psig
1	780	15	3	930	35	6	200	—	9	750	145
2	750	150	4	820	10	7	400	—	10	750	5-10
			5	335	2.5	8	500	—	11	500	0

FIG. 2. Process flow plan of the Tyler decarbonizer unit. Low operating pressure maximizes gas oil yield.

tion of reduced crude along with product also reduces partial pressures, enabling high bottoms cut point. The 12.5 API stock in coker product is, of course, automatically recycled to extinction.

Low pressure in the fractionator, 5-10 psig at the bottom and 2.5 psig at the top, plus stripping steam also aid in maximum gas oil recovery.

Fractionator bottoms are heated in the vertical coker furnace to about 930 F and flashed into the bottom of one of the two coke drums. Coke drum pressure is about 10 psig; the effluent gases leave the top of the drum at about 820 F and flow to the bottom of the fractionator.

Gas Oil Recovery

Gas oil is condensed in the fractionator and drawn off from a well-type tray. The hot gas oil is pumped through heat exchangers to generate steam. A portion of the stream is returned to the fractionator as intermediate reflux, and the net gas oil production sent to storage. The decarbonizing unit is a net producer of steam, an important factor in operating economy.

Gasoline, gas, and stripping steam are taken overhead as vapors, cooled and condensed. The coker gasoline is treated and blended into motor gasoline.

Coking Operations

The two coking drums are used on a 24-hour cycle. While one is engaged in the coking process, the other is available for decoking. Drums are switched at night, and the full drum allowed to cool until the four-man coking crew arrives on the 7:00 a.m. shift. Because of the 24-hour operating cycle, only one decoking crew is required.

The empty coke drum is preheated with superheated steam prior to actual switching. Coker furnace effluent is switched from the full to the empty drum. When the full drum is completely off-stream, a portion of the frac-

TABLE 1. Feed and Product Inspections.

	Reduced Crude	Gasoline	Residue to Coker Furnace	Coker Gas-Oil
API Gravity	26.6	54.0	12.5	28.6
Con. Carbon %	3.62	—	—	—
Sulfur, Wt %	0.436	0.12	—	—
VCM	—	—	—	—
RON-3cc	—	—	—	—
RON-0	—	52.6	—	—
Pour Point	80°	—	—	—
RVP	—	2.8	—	—
ASTM Distillation				
IBP	264	150	—	455
% Off at 400°	3	—	—	—
5%	438	218	—	537
10%	510	238	—	571
20%	572	266	—	614
30%	622	288	—	654
40%	662	303	—	691
50%	684	326	—	727
60%	696	335	—	762
70%	704	346	—	801
80%	716	362	—	843
90%	—	380	—	890
95%	—	390	—	920
EP	—	409	—	—
Recovery	100%	98.5%	—	97.5%
K UOP	11.85	—	—	11.93
Bsdw	0.2	—	—	—
SSU at 100	213	—	—	—
Bromine #	—	28.1	—	—

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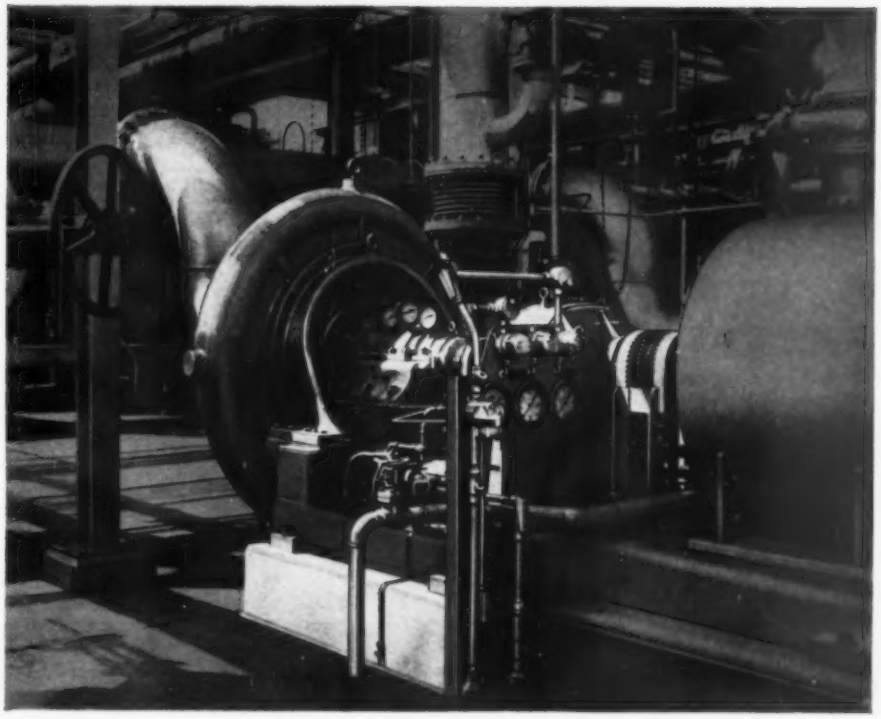

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To satisfy these widely varying requirements, Roots-Connersville centrifugal blowers assure positive control of air delivered to the reaction furnaces. Whatever the conditions may be, they provide the kind of dependability that results in continuous, efficient operation for long periods of time. Whatever the service, you can count on this dependability in Roots-Connersville centrifugal equipment in capacities from 1,100 to over 100,000 cfm.

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tionator stripping steam is cut into it, and purged into the fractionator for about a half hour.

Stripping steam is then cut off and saturated steam is turned in at maximum rate for a half hour, discharging to a blowdown system. Water is then introduced into the drum to cool the coke, and further remove oily residue, and drained out prior to arrival of the decoking crew.

Decoking

Coke is removed by means of a hydraulically-powered drill moving up through the coke bed. After unheading the vessel, an 18-in. pilot hole is drilled 15 ft up into the 10 by 55 ft drum, and the drill withdrawn to the bottom of the vessel.

The three prongs on the drill are then opened, spreading out to within 3 in. of the drum wall. Coke as it is drilled up, falls into a hopper and is fed to conveyor belts to transfer coke directly to a rail car or to a stock pile.

Actual decoking takes only about three hours. The four-man crew needs another four hours for unheading, heading up, and cleanup.

Operating Experience

Downtime has been low, averaging 16 days annually. This is equivalent to a 95.5 percent service factor, a little higher than industry standard for most operating units. Primary mechanical difficulties, common to most units of its type, have included infrequent pressure surges that buckle fractionator trays, occasional coke buildup on trays, and furnace tube replacement. None of these has presented major problems, though, says the Tyler management.

Obviously, the decarbonizing unit has improved refinery realization markedly. The refinery for many years has considered itself primarily as a custom blender of motor and aviation fuels. Addition of the decarbonizer has boosted yield of gasoline to about 70 percent on crude, in effect upgrading residuum to motor gasoline and heating oil.

Coking in the coker furnace-coke drum transfer line has not been a problem. Rather high velocity plus steam injection minimizes this potential problem.

Summing up, three years' operating experience has fully demonstrated the feasibility of low pressure coking. And, no insurmountable problems have been encountered, even during initial startup. This can be considered rather unusual for a new process — especially one that can be as tricky as coking.

★ ★ ★

TABLE 2. Catalytic Cracking Yields on Decarbonized Gas Oil
— Pilot Plant, Once Through Basis —.

	Wt%	Vol%	°API
H_2S	0.2	—	—
C_3	6.9	—	—
C_4	7.4	11.2	—
Debut. Gaso.	34.5	41.0	59
Lt. Cycle	30.9	31.0	29
Hvy. Cycle	12.4	12.0	24
Catalyst Deposit	7.7	—	—

TABLE 3. Analysis of Metals in Coker Gas Oil.

Metal	Coker G-O ppm	Metal	Coker G-O ppm
Fe	0.3	Cu	0.016
Mn	0.004	T	0.02
Cr	0.004	Al	0.08
N	0.2	Mg	0.04
V	0.3	Ca	0.6
Pb	0.06	Na	0.2
Sn	0.004	—	—

TABLE 4. Analysis of Coke Product.

Sp. Grav.	.7211
Moisture	13.0
VCM	10.9
Ash	0.09
S%	1.78
Sol. Salt	0.09
SIO_4	0.04
FE_2O_3	Tr.
CaO	0.02
Na_2O	0.02
Lb/cu ft	45

Industry Mourns Death of Dr. V. A. Kalichevsky

Dr. Vladimir Anatole Kalichevsky died February 4, 1958, at his home in Beaumont, Texas, of a self-inflicted gunshot wound. Internationally known, he was one of America's foremost engineers, authors, and lecturers and was listed in "American Men of Science."

Dr. Kalichevsky was author of "Modern Methods of Refining Lubricating Oils," (1938); "The Amazing Petroleum Industry," (1942); "From Oil Well to Engine," (1952); he was co-author of "Chemical Refining of Petroleum," (1942), and "Petroleum Refining with Chemicals," (1956). He had more than 20 articles published in *The Refining Engineer*, one of which was the series "Fundamentals of Refining." Some 16 patents were held by him and he was co-developer of many petroleum processes. Among these were Thermofor Catalytic Cracking, Continuous Wax Molding, Dualayer Distillate Treating, and Dualayer Gasoline Treating.

Dr. Kalichevsky was born in Tiflis, Russia, in 1895, the son of a Russian general. He attended military academies in St. Petersburg and Poltava, Russia, and was graduated as a second lieutenant from the Corps of Pages of His Imperial Majesty the Emperor of Russia. Upon graduation in 1917, he obtained the equivalent of a PhD degree.

After serving three years in the Russian army he sought refuge in Japan. There he became manager of the topographical department of Chukotsk Peninsula Mining Corporation. In 1921 he emigrated to the United States. He was graduated from the California Institute of Technology in 1924 with a bachelor's degree in chemical engineering. From 1924 until 1929 he was a research chemical engineer with Union Oil Company of California. In 1929 he became a research chemist with Standard Oil Development Company in Elizabeth, New Jersey, and worked there until 1931. On April 15, 1931, he joined Vacuum Oil Company and became associated with the Mobil companies when Vacuum merged with Standard Oil Company of New York in July 1931.

A section leader in the research and development department, Socony Mobil Oil Company, Inc., from 1931 to 1937, Dr. Kalichevsky was promoted to general supervisor in 1937. He continued in this capacity until 1944 when he joined Magnolia Petroleum Company as consulting engineer at their refinery at Beaumont, Texas, a position that he held until his death.

This man was more than a standout in an industry of outstanding men; he was a true giant in a forest of mighty trees. His accomplishments and contributions to American science will long be remembered. We bow our heads and hearts in tribute.

Liquid-Phase Butane Isomerization

Licensed by: Shell Development Company

DESCRIPTION: Normal liquid butane is contacted in a stirred vessel with liquid catalyst consisting of a solution of aluminum chloride in antimony trichloride. Anhydrous hydrochloric acid, which acts as a promoter, is added to the mixture. The reaction produces isobutane with hardly any products boiling outside the butanes.

Dried normal butane, heated to about 180°F, is passed through the catalyst scrubber and charged to the first reactor vessel. A small sidestream of catalyst from the third vessel is contacted with heated feed in the catalyst scrubber to recover $AlCl_3$ and $SbCl_3$, leaving only insoluable $AlCl_3$-hydrocarbon complex sludge. Sludge is rejected periodically from the bottom of the scrubber tower.

Simple fractionation removes catalyst from the isomerizate from the third reactor vessel. Recovered catalyst is recycled to the first reactor vessel. Following light ends removal and HCl stripping, the isomerizate is cooled and caustic washed.

FEED SPECIFICATIONS:	Recommended Maximum
Unsaturates	0.05 Mol %
Sulfur	0.005 Wt. %
Water	0.001 Wt. %
iC_5+	1.0 Mol %

TYPICAL MATERIAL BALANCE:

	Feed		Product	
	Wt. %	Vol. %	Wt. %	Vol.%
C_3	.....	.....	.05	0.06
iC_4	5.00	5.18	60.50	61.47
nC_4	94.65	94.50	37.79	36.99
iC_5+	.35	.32	1.61	1.48
Loss	.....	.....	0.05	.....
	100.00	100.00	100.00	100.00

UTILITIES AND CHEMICALS:

	Per B Net Isobutane
Steam (100 psig)	180 lb
Cooling water (30°F rise)	560 gal
Power	1.3 kwh
$AlCl_3$	0.10 lb
$SbCl_3$	0.04 lb
HCl	0.04 lb
NaOH	0.01 lb

SERVICE FACTOR: 95 Percent

CAPITAL COST: Including 20 percent contingency, bare equipment for a 1000 BPD unit: $240,000

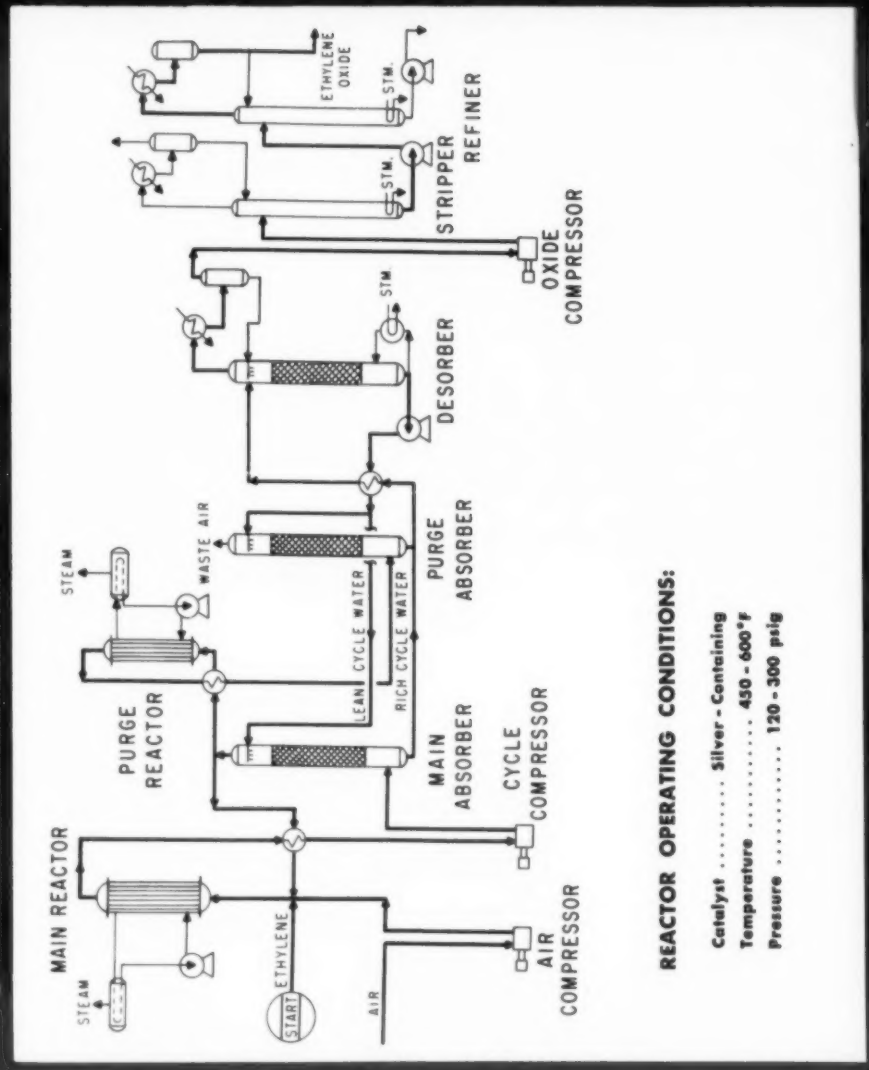
ROYALTIES:

Running: 10¢/B Net iC_4 Made
(5¢/B if Sale to U.S. Gov't.)

Paid-up: 50¢/Annual B Net iC_4 Prod. Cap'y.

Ethylene Oxide

Licensed by Scientific Design Company, Inc.



Ethylene Oxide

Licensed by: Scientific Design Company, Inc.

DESCRIPTION: A silver catalyst is used to oxidize ethylene to ethylene oxide in this process. Feed consists of high purity ethylene, compressed air, and recycle stocks. Temperature of oxidation and heat removal from the exothermic reaction is controlled by an organic heat transfer medium flowing through a multi-tube reactor into steam generators.

Reactor effluent gases are cooled by exchange with recycle gases and then water, and passed to tower where the ethylene oxide is absorbed in a dilute aqueous solution.

Most of the absorber overhead gases are recycled to the main reactor. However, a portion is diverted through a secondary reactor to remove remaining ethylene prior to purging inerts (primarily nitrogen). Gases from the secondary reactor pass through a purge absorber.

Rich solution from the primary and purge absorbers is desorbed with desorber bottoms returning to the absorbers. A partial condenser, shown on the flow diagram, may be used to further enrich the overhead vapor. However, this piece of equipment is optional.

Ethylene oxide vapor is compressed then purified in a conventional distillation train. The carbon dioxide and other light ends are stripped from the oxide in the first column. The second column distills the ethylene oxide from water and other heavier liquids.

CATALYST:

The catalyst contains silver. Catalyst costs are a relatively unimportant factor in manufacturing cost due to long life and durability.

CHEMICAL REACTIONS:

Chemistry of the ethylene oxide process is not complicated, as shown by the following:

(1) $C_2H_4 + \frac{1}{2} O_2 \rightarrow C_2H_4O$

(2) $C_2H_4 + 3 O_2 \rightarrow 2 CO_2 + 2 H_2O$

COMMERCIAL YIELDS:

Weight yield, expressed as pounds of oxide product per pound of ethylene feed consumed, approaches 100 percent in properly-designed plants, corresponding to over 60 mol percent.

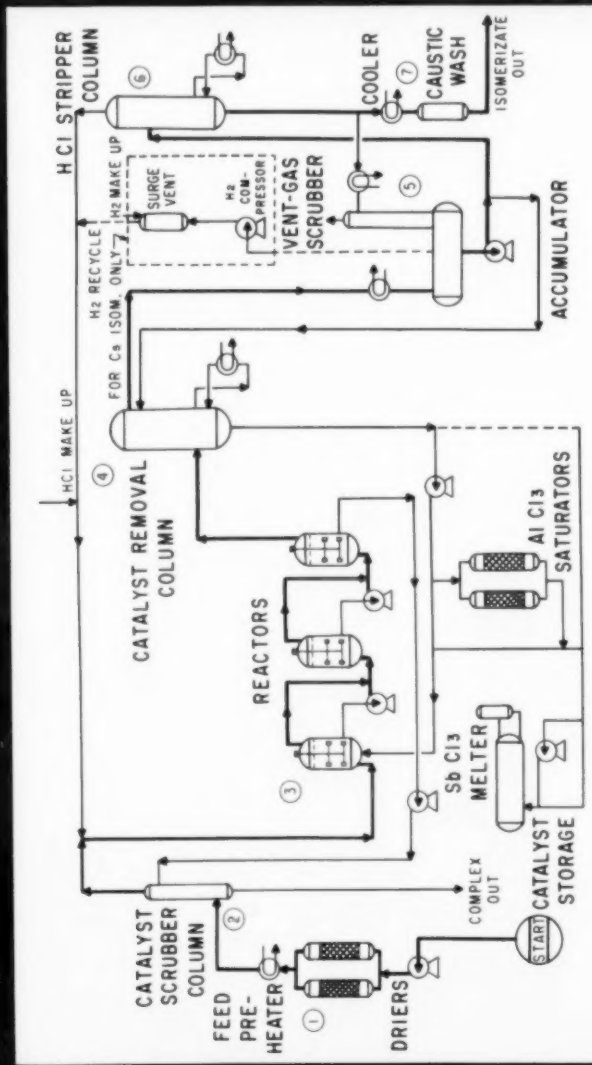
INVESTMENT AND OPERATING COSTS:

Principal cost is the ethylene feed; other raw materials are of no economic significance. Moderate steam and power consumptions are claimed.

Investment for more recently constructed plants has been less than ten cents per annual pound of capacity, based on complete plant within battery limits.

Liquid-Phase Butane Isomerization

Licensed by: Shell Development Company



OPERATING CONDITIONS:

Point	°F	psig
1	70	330
2	180	305
3	195	300
4	180	170
5	100	—
6	—	325
7	140	—

Catalyst ..... Antimony Trichloride Aluminum Chloride (93 Wt %) (7 Wt %)

Temperature ..... 195°F

Pressure ..... 300 psig

Catalyst-Butane Ratio 1

HOW ESSO MEASURES MAINTENANCE DEPARTMENT PERFORMANCE

Bayway Refinery uses indices to determine efficiency

MAINTENANCE and service costs are a very large portion of the expense involved in running a refinery. At Esso's Bayway Refinery, for example, they amounted to roughly 20 percent of the entire cost of operation in 1956. Expressed another way, these costs ran about five percent of the refinery's replacement investment (on a 1954 basis) in 1956. Nearly half the people used to run the refinery are used in maintenance and services.

To control these costs and to measure performance, Bayway Refinery has developed a series of indices. These were described in a recent talk by John Van Schen, with Bayway's cost analysis department. These indices are used to compare the Bayway refinery with other refineries in the Esso and Standard Oil Company (New Jersey) family.

Three overall indices are determined, as follows:

Performance Index	Unit
1. Overall maintenance department manpower utilization.	Total men used per million dollars of plant investment.
2. Overall maintenance manpower productivity.	Percent working time to total time.
3. Maintenance level of refinery.	Percent of perfect 100.

These relatively simple measurements were evolved, and not too easily, over a long period of time, according to Schen. The company had run the gamut of extreme complexity to extreme simplicity in attempting to find reliable performance rating methods. "Taken together," claimed Schen, "we believe these indices adequately measure our maintenance performance."

In a paper presented to the Industrial Plant Maintenance Institute at the University of Wisconsin, Schen explained more fully how the system works . . .

Men per million index . . . "The first index, or as we call it, the men per million index, tells how many total people in the Mechanical Department are used to maintain and service $1-million worth of plant equipment. Everyone — mechanics, supervisors, truck drivers, janitors, etc., — is included. The only people excluded, for obvious reasons, are the people engaged in capital construction work and work performed and charged to outsiders. We have found that this index is simple enough to permit ready comparison between other refineries, particularly competitive ones, and yet accurate enough to show up significant variations from year to year and between refineries.

"This index varies between the refineries mentioned from a low of around 3.5 men per $1 million to a high of around 5.5 men per $1 million. We think that, by and large, this reflects differences in efficiency rather than differences due to the type of equipment or processes. Here, we are comparing entire refineries with about the same types of equipment, producing the same general line of products.

"Within Bayway Refinery there are six maintenance areas. Each month we look at the mechanical efficiency (men per $1 million) in each area. Since some areas include fluid catalytic cracking units and others tankage, the indices vary widely. Again, however, from comparisons with others, we have a fairly good idea of what the various areas should be doing. This internal area measurement system started a little over a year ago . . . and we are continuing to develop better overall standards of performance as we go along. Thus far we have found that area supervisors like the system since it "tells the score" and permits them to compare their progress with others."

Worker Productivity . . . "We also measure how many minutes of a day a man is working. Along with this we also determine why he isn't working. The overall mechanical index, mentioned previously, measures the effect of many things, such as the effect of new equipment and new processes, in addition to the effect of worker productivity. In this index of productive time, we try to gage the effect of training, better scheduling of men, and materials to the job, etc., to develop a deeper insight into the causes for worker delays.

"We measure worker productivity by means of work sampling. Briefly, this is how we do it:

"Experienced maintenance personnel makes a number of instantaneous observations of worker's activity on an absolute random basis. These observations are recorded against pre-selected types of activity, one for each work element it is desired to measure. The simplest study would measure only the two elements, working or idle. Thus, the percentage of the total individuals observed, found working would represent the percent activity or the productivity level. Since the degree of accuracy is dependent upon the number of observations, a greater number of observations taken will give a higher degree of accuracy. Work Sampling is not limited to observations of working or idle, but can be used to determine any number of job delay causes, their magnitude, and even worker pace if so desired.

Level of maintenance . . . "Obviously we could show low mechanical costs and a good mechanical index, in men per $1 million, for awhile by letting the plant run down. Any performance measurement, therefore, has to indicate the general level of maintenance. We have developed an index which we think shows this.

"This index, called plant maintenance level, is a percentage evaluation of several factors, that have a direct bearing upon the physical condition of the refinery's maintenance. The five factors used (listed below) are each given a weighted value and are control data that are normally required for routine checks of maintenance operations. Consequently, we are simply applying data that is available for routine business to help us evaluate monthly the condition of our plant."

Temperature ..... 195°F
Pressure ..... 300 psig
Catalyst-Butane Ratio 1

3	195	300
4	180	170
5	100	—
6	—	325
7	140	—

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Maintenance Level Factors

1. *Amount of overtime worked.*
(Low overtime normally reflects good planning, good maintenance level.)
2. *Amount of work backlog.*
(An increase in backlog over a good norm means maintenance is slipping.)
3. *Plant appearance.*
(This factor is measured numerically by the amount of litter and unsafe conditions noted in predetermined areas by random routine inspections. A sloppy plant is poorly maintained.)
4. *Number of overdue inspection items.*
(Certain critical pieces of equipment must be inspected at scheduled intervals. When these run overdue, they indicate maintenance is slipping.)
5. *Keep equipment out of service for repairs.*
(This is a spot appraisal of the number of pieces of equipment out of service for repairs at a set time each month. A high number, above a set percentage of total equipment, reflects poor maintenance.)

"In conclusion we in Esso believe that the performance measurement of the maintenance function is essential to low cost maintenance. We think that the indices used must simply and accurately tell both the plant and the Maintenance Department management how efficiently men and equipment are being utilized. The importance of high efficiency in this area of a plant's operations will increase with the trend toward more intense competition in the market place and increased mechanization within the plant." ★ ★ ★

WESTERN PETROLEUM REFINERS ASSOCIATION SETS ANNUAL MEETING PROGRAM

TULSA, Oklahoma . . . Paul D. Williams, executive secretary of the Western Petroleum Refiners Association, has announced that the program for the Association's 46th annual meeting is just about complete. Williams added that an estimated 1500 persons are expected to attend the March 24-26 meeting at the Hilton Hotel in San Antonio, Texas.

The three-day program will include technical sessions on asphalt, motor and diesel fuels, lubricants, refining economics, refining processes, and recent developments. In addition to the technical sessions, there will be two general sessions, each of which will feature a speaker of national prominence. A feature of the Tuesday general session will be an address by WPRA President Harry J. Kennedy, Continental Oil Company, Houston.

Asphalt symposium. A feat speaker at the asphalt symposium, Monday, March 24, is J. E. Buchanan, president of the Asphalt Institute, College Park, Maryland. Buchanan, who addressed the Association's 43rd annual meeting, will speak on the subject "A Fresh Look at the Road Program — Its Implication to the Oil Industry." Other speakers at this session include S. W. Downer, III, editor of *The Refining Engineer*, Dallas, Texas. Main theme of Downer's talk will be "Correlating Asphalt Sales and Manufacturing Capacity," which will be based on the results of a recent survey conducted by *The Refining Engineer*.

Technical papers on fuel products. T. B. Rendell, Shell Oil Company, New York City, will preside at the technical session Monday afternoon. This session, sponsored by the Motor Fuels and Diesel Fuels Committees, will feature three papers concerned with the relationship existing between the automotive industry and the petroleum industry. Speakers at this session include K. G. Mackenzie, Chicago, who will discuss "Where Do We Go From Here," W. S. James, The Fram Corporation, will present a companion paper dealing with the field of lubricating oils, and D. L. Pastell, E. I. duPont de Nemours, will present a paper entitled "Current Engine Fuel Relationship." DuPont co-authors are W. E. Morris and J. J. Greytak.

"Well, I'm a chemist, see — What are you?"

Processing papers schedule. C. M. Ridgeway, manager of the Pure Oil Company research center at Crystal Lake, Illinois, will preside at the March 25 technical session. Speakers and the subjects they will discuss are: T. W. Legatski, Phillips Petroleum Company, co-authors are Mrs. O. C. Bridgeman, and E. W. Aldrich, "Trends in Motor Fuel Quality"; W. T. Service, The Pace Company — co-authors are R. E. Payne and W. E. Askey — "Economic Production — Present and Future — of Motor Gasoline"; L. D. Stewart, D-X Sunray Oil Company, – "Profit Making Functions in Refining."

D. R. Johnson, general manager of manufacturing for Continental Oil Company, Houston, Texas, will preside at the technical session, Wednesday morning, March 26. Speeches for this program include "Instruments For Heater Oil Production," S. F. Kapff and J. C. Rhodes, Standard Oil Company, (Indiana); "Alkar and Butamer — Two New Processes For Refiners," will be given by Henry W. Grote — co-authors are Vladimir Haensel and Carl B. Linn — Universal Oil Products Company, and "The Whiting Fire and Rehabilitation," by J. C. Ducommun, Standard Oil Company, (Indiana).

NEW Refining Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

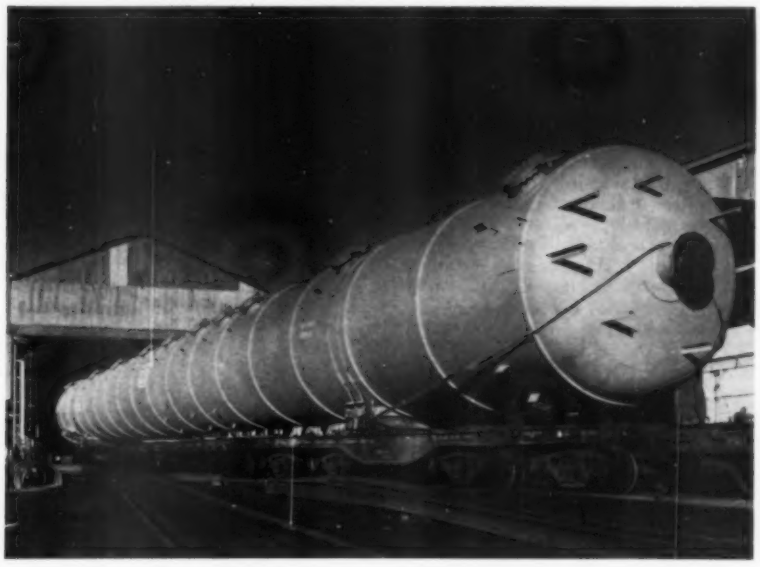
Largest Vessel Ever Moved By Rail

How to ship a 294 ton, 208 ft long and 14 ft diameter fractionating column from Houston to Lake Charles, La. presented a problem to Tellepsen Petro-Chem Constructors. Problem now has been worked out by Tellepsen who engineered and are constructing a butane isomerization unit and splitter for Cities Service Refining Corporation in Lake Charles.

Column was transported by Southern Pacific Lines on 6 special railroad flat cars. Anchored only to the second and fifth cars, each of the supporting cars had a device which enabled the column to pivot when the train rounded a curve.

Due to the length and size of the column, it was necessary to impose a maximum speed of 10 mph for the trip. At 1 curve in the track, the column was suspended approximately 13 ft over the railroad's roadbed. Column is being set on a concrete foundation which contains a total of 375 cu yd of concrete reinforced with 30 tons of steel. Forty anchor bolts secure the tower to this foundation. *Tellepsen Petro-Chem Constructors, a division of Tellepsen Construction Co.*

Circle number (41) on reply card.



Automatic Pressure Logger

Automatic digital data logger scans sequentially 24 or 48 pressure lines into a single transducer. Extremely low switched volume results in high accuracy pressure measurements by minimizing air flow disturbance at probe orifice, pressure drop at probe orifice and in pressure lines. The Data-Master Type 5 features high accuracy electronic digitalizer, visual data display, portability, low cost, 24 or 48 inputs. *Hanson-Gorrill-Brian, Inc.*

Circle number (42) on reply card.

New Fire Hose — Light, Flexible, Tough

A new fire hose, designed primarily for use by the petroleum and chemical industries, has been placed on the market. Light in weight and flexible, the hose has a guaranteed test pressure of 400 lb. It is constructed of Neoprene cover and tube with Dacron filler and cotton wrap. *Goodyear Tire & Rubber Co.*

Circle number (43) on reply card.

New Digitizer for Mass Spectrometers

An all-electric digitizer is expected to materially widen the use of mass spectrometry by cutting the present time-consuming process of measuring and tabulating peak heights from the mass spectrometer's oscillogram. Known as the MASCOT, the instrument is available from Consolidated Electrodynamics.

It is a completely unprogrammed digitizer designed to provide tabulated digital conversion of the analog output from CEC's Type 21-103C mass spectrometer. It converts the amplitude and true mass number of each mass-spectrum peak (except metastable peaks) into a signal to a parallel-entry type paper-tape printer. A special printer is available for printing and simultaneously actuating an IBM card punch, or paper tape punch. Operating at the speed of a normally scanning mass spectrometer, the MASCOT eliminates the time necessary to manually identify and measure peaks on an oscillograph record. *Consolidated Electrodynamics Corp.*

Circle number (44) on reply card.

New Steam-Hydraulic Jet Cleaner Available

Products of 2 manufacturers of heavy-duty cleaning equipment—Clayton Manufacturing Company and Sellers Injector Corporation — are combined in the Clayton-Sellers Steam and Hydraulic Jet Cleaner. The new combination steam and hydraulic jet cleaning unit, Model CS 628, has been designed especially for use in heavy-duty industrial cleaning jobs in off-highway, marine, railroads, truck transport, petroleum, aircraft and similar industries. According to the manufacturers, its versatile design makes it easily adaptable for use wherever steam or hydraulic cleaning is needed. *Clayton Manufacturing Company.*

Circle number (45) on reply card.

New Pressure Gage Records On 3-Inch Strip Chart

A recording pressure gage which uses a 3-in. strip chart has been announced by The Bristol Company. The gages are offered in ranges from 0-3 psi up 0-60 psi. Elements in various ranges are offered in ni-span C, beryllium copper, and phosphor bronze. The recording chassis is interchangeable, and can be plugged in without the use of tools, from the front of the panel. *The Bristol Company.*

Circle number (46) on reply card.

Flow Meter for Half-Inch Lines

Magnetic Flow Meter, manufactured by Foxboro, is available for ½-in. flow lines. It will be particularly useful in ratio flow control systems where small flows are ratioed to larger ones.

The smaller meter offers the full advantages of the larger instrument (1-in. and up).

Transmitter unit consists of a Teflon-insulated nonmagnetic flow tube containing flush-mounted metallic electrodes and surrounded by an a-c electromagnet. When a conductive liquid passes through the tube, an alternating voltage is set up between the electrodes which varies linearly in proportion to the volume rate of flow. Lead wires from the electrodes transmit this voltage output to a Foxboro Dynalog Recorder, producing a chart record in appropriate units of flow. *The Foxboro Company.*

Circle number (47) on reply card.

Single-Unit Hot Gas Washer

A single-unit hot gas washer which eliminates most air pollution problems and resists temperatures up to 2000 F, was announced by Lehigh Fan & Blower Division. A compact unit, the gas washer can be used for incinerators, melting furnaces, chemical processes or other conditions where hot air or gases present a dust pollution problem.

The dynamic hot gas washer is available with manual or automatic sludge removal. For economy where the dust load is light, smaller units are equipped with a recirculating water pump, water level float valve and complete piping. Capacity range is dependent on use. *Lehigh Fan & Blower Division, Fuller Company.*

Circle number (48) on reply card.

Transistorized Electronic System To Measure Liquid Levels

A new transistorized electronic system for measuring the level of liquid in remotely located storage tanks, with accuracy of performance, reliability and self-checking features, was introduced by Texas Instruments. Called the "Data-Gage," the system was designed and developed especially for the oil and chemical industries to control inventories, quickly and accurately, in large installations such as tank farms. It can be used, however, where liquid materials are stored in large tanks.

Major components of the Data-Gage system are a receiver console, field selector unit, and liquid level gage embodying a float of new design. The entire system may be installed at the tank site, or the receiver console may be located in a remote office at any distance from the tanks. Direct wire, telephone, carrier or microwave transmission may be employed. Up to 100 tanks or stations may be monitored on a single system, with liquid depth up to 64 ft in each tank measured with an accuracy of 1/16 in. *Texas Instruments Incorporated.*

Circle number (49) on reply card.

New Temperature Control with "Accu-Vision" Dial

A mercury-actuated indicating temperature control designed by Raymond Loewy Associates, features a novel dual mounting design and greatly improved readability. Said to be accurate to within ½ percent of scale range, the controller will sense, indicate and control processes within the extreme ranges of –30 to 1100 F. It is available in 10 different scale ranges. Designed into the instrument is an exclusive readability feature called "Accu-vision" which is said to guarantee accuracy in setting and reading the instrument. *The Partlow Corporation.*

Circle number (50) on reply card.

Diaphragm Prevents Leaks from Metering Pumps

For metering toxic, obnoxious, corrosive and/or costly chemicals, Milton Roy has introduced a new controlled volume diaphragm pump. These new controlled volume pumps have Teflon diaphragms sealing the liquid ends from the plunger and housing. The plunger displaces hydraulic fluid which in turn strokes the diaphragm to impart pumping action through double ball checks. There is no mechanical connection between the diaphragm and the plunger. Available with maximum capacities from 1.1 to 138 gal per hr and pressures to 2000 lb per sq in., these new diaphragm pumps have manual or automatic capacity adjustments from 0 to 100 percent. *Milton Roy Company.*

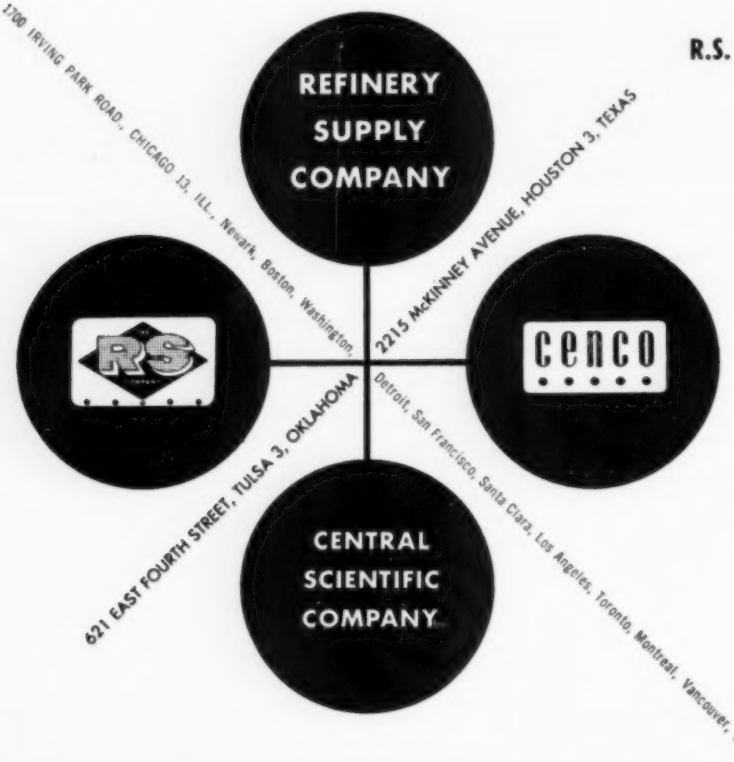
Circle number (51) on reply card.

Solenoid Operated Drain Valve

A solenoid operated drain valve is available from the Automatic Switch Company. The Bulletin 8339 is a direct acting type solenoid controlled valve having excellent draining characteristics. The absence of cavities or obstructions in the valve itself eliminates the collection of foreign matter and a quick clean out plug, easily accessible, assures clean drainage.

The valve has all iron construction, and stainless steel seat, including a watertight (NEMA 1V) solenoid enclosure. Soft composition disc and stainless steel seat provide tight shut-off on 5 ft head pressure. Available in 1½ and 2 in. sizes — valve operates on 15-w a-c and may be supplied for most standard voltages and frequency. *Automatic Switch Company.*

Circle number (52) on reply card.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NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Special Metal Gaskets

Metallo Gasket Company has made available a new bulletin on various type gaskets, raschig and lessig rings and valve discs. New graphs give specialized data for applications in various flanges and fittings. Bulletin gives complete listing of types and styles produced with recommendations for application. Metallic raschig and lessig rings are discussed with range of metals and specifications listed graphically. Size and type of valve discs are shown with methods of manufacture. Custom applications of valve discs are also discussed. *Metallo Gasket Co.*

Circle number (53) on reply card.

Improve Storage Tank Maintenance

"Storage Tank Cleaning and Paint Stripping" is the title of the second Refinery Maintenance Bulletin, published by Oakite Products. Bulletin discusses first the cleaning of tank interiors by spray application of detergent solution to remove medium heavy soils, or by fogging with solvent followed by spraying and soaking to remove heavier soils. Cleaning of exterior tank surfaces with solvent or alkaline detergent is then discussed, and is followed by a section on paint stripping. *Oakite Products, Inc.*

Circle number (54) on reply card.

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Developing Processing Data

A research and testing laboratory for solving problems in drying, evaporation, extraction, mixing, crystallization and other related processes is described in a bulletin published by Buflovak Equipment Division. *Buflovak Equipment Division, Blaw-Knox Co.*

Circle number (55) on reply card.

Transistorized Data Processor

A new bulletin on Philco Corporation's Transac S-2000 transistorized data computor has been released. The bulletin describes new control and flexibility along with tape specifications. Ease of installation, cost of operation and optional equipment are also discussed. *Philco Corp.*

Circle number (56) on reply card.

New Precision Switches

The latest issue of the Micro Switch publication is aimed at the design engineer and other users of precision switches. This issue includes many new types of switches which are being offered, including a "Plug-in Limit" switch which can be replaced on a machine in a matter of seconds. Designers working with problems of high temperatures are brought up-to-date in another article on the latest developments in high-temperature switches. Helpful application examples described include an indexing machine, an elevator control, submersible pump, and an automatic metal spinning machine. *Micro Switch, division of Minneapolis-Honeywell Regulator Co.*

Circle number (57) on reply card.

Bulletin on Vertical Pump Installations

Layne & Bowler Pump Company has released a new bulletin on their vertical pump line. Brochure discusses various verti-line close-coupled turbine pump installations and gives design specifications for head-capacity range. Pumps are cataloged according to application and operating conditions. System simplifies the selection of a specific pump for a specific operation. *Layne & Bowler Pump Co.*

Circle number (58) on reply card.

Titanium Tubing Characteristics

Engineers and others responsible for the design and operation of processing equipment will be interested in the reprint of an article titled, "Present Status and Future Potential for Titanium Tubing." This 8-page article describes the involved method of producing titanium tubing and outlines briefly its many characteristics. The article explains why titanium tubing is uniquely immune to many corrosive conditions which have long been the "number one problem" of process engineers. *Babcock & Wilcox.*

Circle number (59) on reply card.

Data Slide Rule for Speed Variators Available

Bulletin GEA-6643, 16 pages illustrated with 4-color photographs and diagrams, describes General Electric's new line of packaged direct-current adjustable speed drives. Included is a power unit data slide rule for calculating case dimensions, horsepower, speed range, power unit weight, and motor frame size. Used wherever accurate adjustable speed is required, the Speed Variators feature a static excitation system using silicon rectifiers for decreased maintenance, and a new amplistat regulator to accurately compensate for load changes. *General Electric Company.*

Circle number (60) on reply card.

Eleven New Electro-Mechanical Controls

Tipptronic, Inc., has issued a 4-page Bulletin (AC-3) and a 2-page Bulletin (AC-4), describing 11 recently developed control devices. Each unit demonstrates the principle that, wherever a chemical or mechanical function can be measured electrically, controls can be devised to keep machinery operating at peak efficiency safeguard important processes and prevent or warn of machine damage. *Tipptronic, Inc.*

Circle number (61) on reply card.

Techniques and Applications of Thin-Film Processing

A new processor has been introduced by the Rodney Hunt Machine Company. The story of this unit is presented in a 24-page, full color catalog.

The first section of the catalog authoritatively reviews the basic principles and techniques of thin-film processing. The middle section of the catalog is devoted to a complete presentation of the new Turba-Film Mark II Processor, with details of refinements and improvements plus design, engineering and operating data. In the last section typical applications in the chemical and other process industries are illustrated and described, with a commentary outlining the problems involved and how a Turba-Film Processor provided the answer. *Rodney Hunt Machine Company.*

Circle number (62) on reply card

Impregnated Clothing Protects Workers

Head-to-toe, foul-weather protection featured in its newly introduced line of polyvinyl chloride-impregnated North PVC garments is described in a new bulletin. The 2-color bulletin reviews and illustrates the company's new all-weather protective clothing for personnel engaged in outside occupations. *Jomac, Inc.*

Circle number (63) on reply card.

How to Design Multicomponent Fractionators

Reprinted from December 1957 issue of *The Refining Engineer*, a straightforward, simplified method of distillation towers is presented. Use of "key components" to simplify calculations is detailed. Methods include design for reflux, sidestreams, alternate feed methods.

Send 50¢ in coin for single copy, (additional copies 25¢ each) to:

The Refining Engineer
Reader Service Department
Box 1589
Dallas 21, Texas

the Pipeline Engineer

Oil..Gas Products Pipelining

How to save 20% in joining a pipe line

Line-up and welding costs can take a big part of your pipe line construction dollars. But here is how Armco Welded Steel Pipe can reduce these costs by as much as 20 per cent.

Armco Pipe is supplied in standard 50-foot lengths instead of the ordinary 40-foot or double-random lengths. This means at least 20 per cent fewer field joints. Line up and welding time is reduced and you have fewer sections to handle.

What's more, the wide range of diameters (6 to 36 inches) and wall thicknesses ($^9/_{64}$- to $^1/_2$-inch) available in Armco Pipe lets you make the most economical choice to meet your specific requirements.

Use Armco Welded Steel Pipe to meet requirements in the Natural Gasoline and Natural Gas Divisions and wherever else you need dependable line pipe. Mail coupon below for prices and delivery time. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 3968 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. Export: The Armco International Corporation.

Armco Drainage & Metal Products, Inc.
3968 Curtis Street, Middletown, Ohio

Send me prices and delivery time on Armco Line Pipe. I am interested in the following: diameter_____

wall thickness_____ quantity_____

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

ARMCO®

Armco Welded Steel Pipe

UNIBOLT – the best way to close a pipeline opening
Unibolt hinged scraper trap and blowdown closures started a new trend . . . away from heavy, multi-bolt blind flanges. Release only two bolts and these modern closures swing open like a door. The self-sealing gasket is oil-resistant, troublefree, long-lasting. Unibolt closures are available in sizes up to 42", ratings to ASA 900.
Write for a copy of the new Unibolt Pipeline Catalog No. PL-570.
UNIBOLT
THORNHILL CRAVER CO.
P. O. Box 1164, Houston, Texas

PIPELINE DEVELOPMENTS

★ ★ ★

Roundup of Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipeline projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Act Oils Toronto, Ontario, Canada	350		Line from Peace River area in British Columbia, thru Pine Pass to Prince George, westward to Bella Coola terminus on Pacific Coast
Afrique du Nord Development Societe	850	18	Hassi-Messaoud field, Algeria, to Mediterranean port
Alaska Yukon Pipe Lines, Inc.	254	—	Valdez to Tok Junction, Alaska
Alborz Oil Company	1000	38	Qum, Iran, to Alexandretta, Turkey
Argentine Government (YPF) Buenos Aires, Argentina	640	12	Campo Duran fields to Rosario
Atlantic-Cities-Service-Continental-Gulf-Phillips-Texas-Sinclair	Approx. 385	26	Midland, Texas, area to Houston
Bituminous Oil Pipeline, Ltd. Calgary, Alberta, Canada	250	—	McMurray to Edmonton, Canada
Bolivian Government (YPFB) La Paz, Bolivia	215	8, 10	Interior of Bolivia to Arica, Chile
Cape Pipe Line Company Philadelphia, Pennsylvania	200		Large diameter from Delaware Bay to Greater Philadelphia area refineries
Creole Petroleum Corp. Caracas, Venezuela	86	30	Temblador field to Caripito, Venezuela
Gillette Pipeline, Inc., and A. W. Hartwig, Inc.	102	—	Dead Horse Creek field to Casper, Wyoming
Great Northern Railway Co. St. Paul, Minnesota	600	12–20	Williston Basin to St. Paul-Duluth-Superior, Wisconsin-Minnesota area
Iraq Petroleum Co. London, England	Approx. 600		Kirkuk field to Iskenderun, Turkey
Jayhawk Pipe Line Corporation Wichita, Kansas	242	10, 12	Meade County, Kansas, to Valley Center
North-West Oil Pipelines Company	210		Wilhelmshaven, on the North Sea, to industrial Ruhr area of West Germany
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Oil Field Pipe Line, Inc. and Panhandle Eastern Pipe Line Co. Kansas City, Missouri	200	8, 12	Elkhart to Ellinwood, Kansas
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Shell Pipe Line Corporation Houston, Texas	100		Southwest Pass Terminal to Norco, Louisiana, Refinery
Southern Kansas Pipe Line Company	310	6, 10	Greenwood pool, near Colorado line, thru Liberal to Arkansas City, Kansas
Trans-Border Line Company	110		Skagway, Alaska, to Whitehorse, Yukon Territory
17 American, English, French and Dutch Companies	1500	38–40	Middle East producing areas to Mediterranean Coast in Turkey
Yacimientos Petroliferos Fiscales Buenos Aires, Argentina	375-434		Challaco, Neuquen Province, to Arroyo Parejas

PRODUCT LINES

Name of Company	Miles	Size	Location
American Pipe Line Co. New York, New York	1910	8–26	Beaumont, Texas, to Newark, New Jersey
Conn-Mass Pipe Line, Inc.	328	6, 8, 16	In Connecticut, Massachusetts, New Jersey
Hydrocarbons Pipelines, Ltd. Winnipeg, Manitoba, Canada	800	6–8	Edmonton, Alberta, to Fort William, Ontario
Laurel Pipe Line Company Pittsburgh, Pennsylvania	350	14–24	Philadelphia to Pittsburgh to Cleveland
M.K.&T. and New York Central Railroads	2000	—	Houston-Kansas City-St. Louis-Indianapolis-Cleveland-Syracuse, New York, with branches to Chicago and Detroit
Mene Grande Oil Company Caracas, Venezuela	60	6	Anaco to Puerto La Cruz, Venezuela
Northwest Pipeline Corporation Salt Lake City, Utah	350	8–10	Four Corners to Salt Lake City, Utah
Service-Continental-Sinclair-Phillips	550		Salt Lake City, Utah, to Spokane, Washington
Underground Storage and Exploration, Inc.	393	6, 8, 12	Moundsville, West Virginia, to Newark, New Jersey, with laterals to Mauch Chunk, Marcus Hook, and Philadelphia

Says Henry J. Kaiser:

"I confess I was not always advertising-conscious..."

Management "learns new tricks"

...THANKS TO ADVERTISING!

"American management cannot afford to relegate advertising to a secondary role. Management cannot afford to budget funds begrudgingly to advertising and then proceed to forget it, except perhaps to make an occasional carping criticism. Instead, advertising men must be taken closely into inner management counsels—for able advertising men can make a fantastically tremendous contribution to a company. I confess that I was not always advertising-conscious. In many years as a builder, I wouldn't permit the Kaiser name to be painted even on a steamshovel. If I have today reversed this attitude completely, it is because advertising has proved its worth—many times over—in practical business applications. Now, our whole organization is advertising-minded. Top management should take constant interest in the advertising program to help infuse it with ideas, creative imagination and the organization's spirit. Top management should give real attention to the information supplied by its advertising agency on media and on customer opinion surveys. Otherwise, advertising cannot do the effective job that is required for the company to survive... to grow... and to serve an ever-widening circle of customers with better and better products."

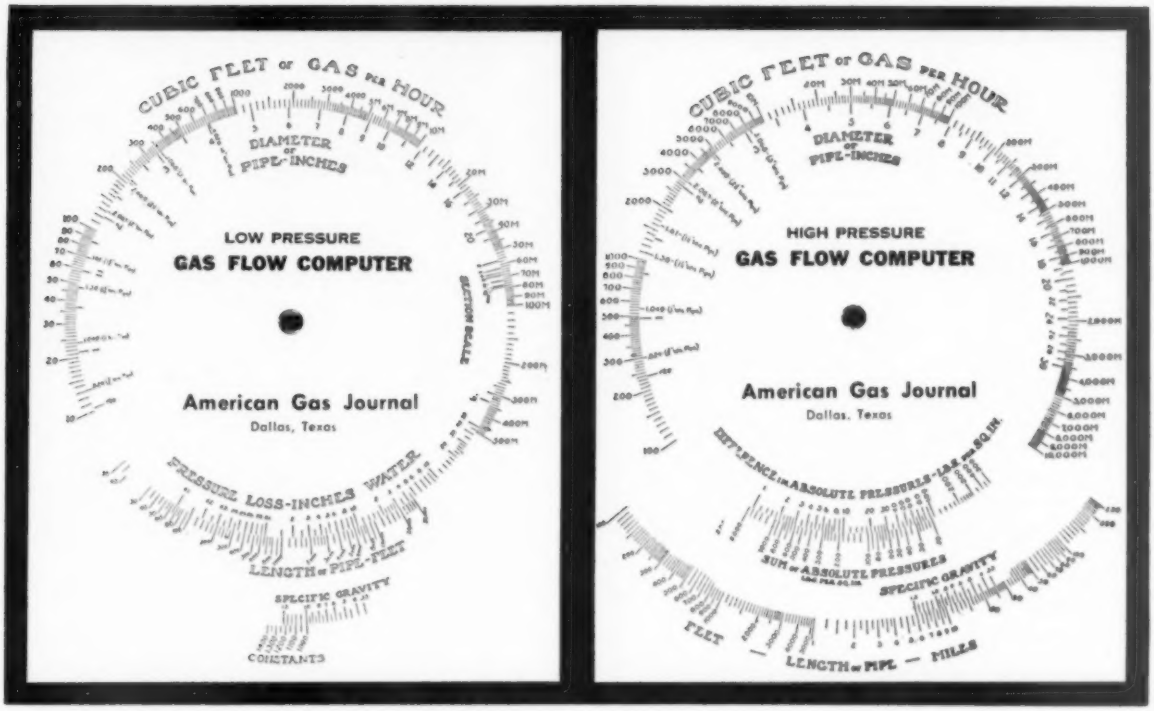
Henry J. Kaiser
CHAIRMAN OF THE BOARD

Thanks to the advertising pages of the trade press, American Industry today has a wide choice of advanced techniques and improved tools and materials. This speeds production, steps up quality, cuts production costs. Then advertising, in return, lowers selling costs to the consumer. Result:

AMERICA IS A BETTER AMERICA—THANKS TO ADVERTISING!

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Speed up your calculations on pipe sizing, pressure drop, flow with the American Gas Journal . . .

GAS FLOW COMPUTERS

For LOW Pressures

Cubic feet of gas per hour	10 to 500M
Pipe diameters	¾-in. to 48-in.
Pressure loss (inches)	.01 to 50
Specific gravities	.35 to 1.5
Constants	1000 to 1400
Pipe length (feet)	30 to 30,000

For HIGH Pressures

Cubic feet of gas per hour	100 to 10,000M
Pipe diameters	¾-in. to 30-in.
Difference in absolute pressure to	500 psi.
Sum of absolute pressures	20 to 2,000 psi.
Specific gravities	.35 to 1.5
Pipe length (feet)	100 to 5,000
Pipe lengths (miles)	1 to 250

The computers are printed on heavy durable plastic, enclosed in Fabrikoid cases with complete instructions for their use.

PRICE: $7.50 EACH

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AMERICAN GAS JOURNAL

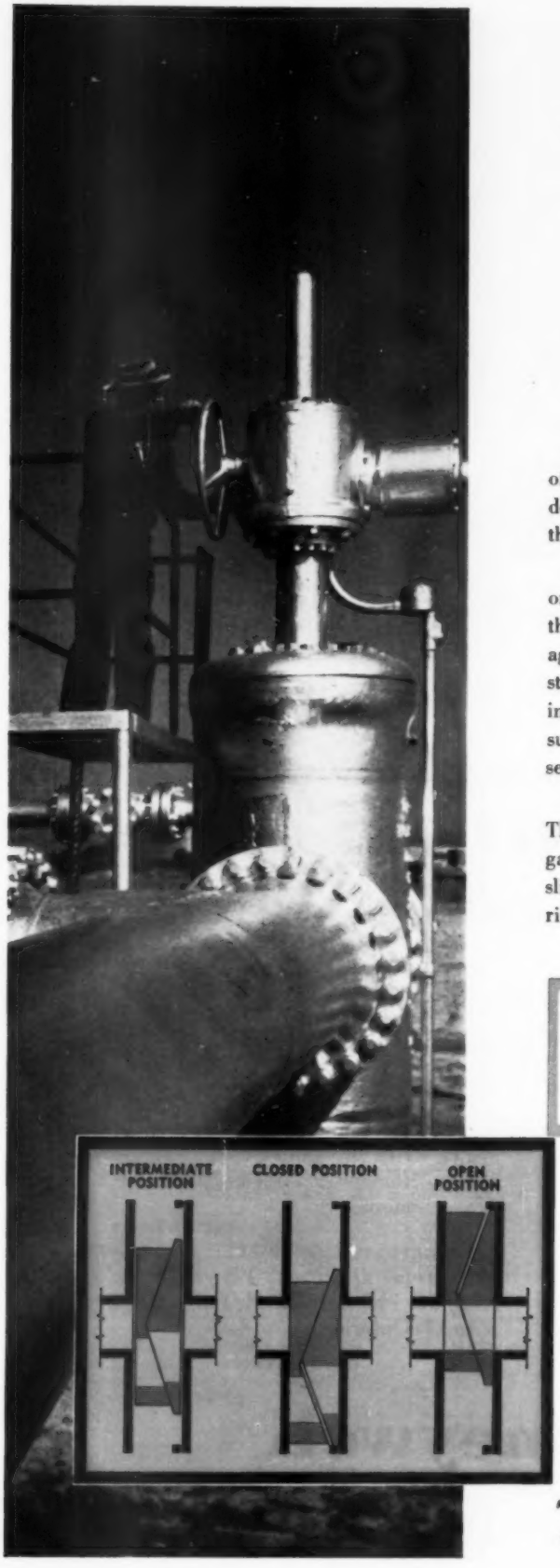
P. O. BOX 1589 • DALLAS 21, TEXAS

PRODUCT LINES

Name of Company	Miles	Size	Location
Union Oil Company of California Los Angeles, California	815		Shale oil plant, Rifle, Colorado, to Los Angeles area
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U.S. Canadian border to Winnipeg

GAS LINES

Name of Company	Miles	Size	Location
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofogasta, Chile
Argentine Government (YPF) Buenos Aires, Argentina	815		Campo Duran fields to Buenos Aires
Arkansas Louisiana Gas Company Shreveport, Louisiana	300		Main and gathering lines Louisiana-Texas Gulf Coast
Coastal Transmission Corporation Dallas, Texas	574 414	22–26 Var.	McAllen, Texas, to Baton Rouge, Louisiana Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company Colorado Springs, Colorado	917	4–34	New lines, loops, replacements in Texas, Colorado, Nebraska, New Mexico, Kansas, Oklahoma
Cuban Gas Transmission Company (Edwin Pauley) Los Angeles, California	1000		Mexico to Florida via Cuba
Eastern Shore Natural Gas Company Salisbury, Maryland	124	6, 8	Transmission line and facilities in Delaware and Maryland
Edison Securities Company Los Angeles, California	130		San Joaquin Valley to Los Angeles
El Paso Natural Gas Company El Paso, Texas	599	6–30	New lines and loops, New Mexico and Arizona
Houston Texas Gas & Oil Company Houston, Texas	942.6	12–30	Baton Rouge, Louisiana, to Miami, Florida Laterals to serve Florida distributors and industrial users
Iron Ranges Natural Gas Co.	120 63	6, 12 12	Mesabi Iron Range to northern Minnesota North Shore of Lake Superior
Michigan Wisconsin Pipe Line Company Detroit, Michigan	638	4–24	Laterals and loops in Wisconsin, Michigan, Missouri, Illinois, Indiana
Midwestern Gas Transmission Company Houston, Texas	2067	3–24	Main line from U.S.-Canadian border near Emerson, Manitoba—Noyes, Minnesota, to Portland, Tennessee Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Missouri Transportation Corp. Springfield, Missouri	280	16	Delaware County, Oklahoma, to St. Louis, Missouri
Mookl Chemical & Gas Corp. Tulsa, Oklahoma	169	16	Pottawatomie County to Delaware County, Oklahoma
Natural Gas Pipeline Company of America Chicago, Illinois	416 337	36 30	Loop from Beatrice, Nebraska, to Joliet, Illinois Loop from Fritch, Texas, to Beatrice, Nebraska
Niagara Mohawk Power Corp. Syracuse, New York	196	2–16	Central, eastern, and northern New York
North Carolina Natural Gas Corp. Houston, Texas	625	2–16	Intrastate line in North Carolina
Northern Natural Gas Company Omaha, Nebraska	1355	2–30	New lines and loops, Minnesota, Wisconsin, Alberta, Texas, Oklahoma, Kansas, Nebraska, Iowa
Northern Plains Natural Gas Company **(subsidiary of Northern Natural Gas Company)** Omaha, Nebraska	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Pacific Gas & Electric Company San Francisco, California	1300	36	Alberta, Canada, gas fields to Antioch, California
Petroleos Mexicanos Mexico City, Mexico	130	22	Reynosa to Monterrey
Piedmont Gas Co. Hickory, North Carolina	78	2–8	In Gaston, Lincoln, Catawba, Caldwell, and Burke counties, N. Carolina
Southern California Gas Co. **Southern Counties Gas Co.** Los Angeles, California	83	34	From Coles Levee to Newhall
Southern Natural Gas Company Birmingham, Alabama	371	4–20	Various lines in Louisiana and offshore
Tennessee Gas Transmission Company Houston, Texas	556 76 163 39 12 50	30 24 30 26 26 26	South of New Orleans to Portland, Tennessee Coudersport, Pennsylvania, to Hamburg, New York Loop from Portland, Tennessee, and Winchester, Kentucky, to Lancaster and Morehead, Kentucky Loop from Catlettsburg, Kentucky, to Broad Run, West Virginia Loop south of Mercer, Pennsylvania Loop from Morehead, Kentucky, to Catlettsburg, Kentucky
Texas Eastern Penn-Jersey Corporation Shreveport, Louisiana	65	30	Loop from Delmont, Pennsylvania, to Lambertville, New Jersey
Trans-Canada Pipe Lines, Ltd. Calgary, Alberta, Canada	492 48	30 24	New line from Kapuskasing, Ontario, to Sheridan, Ontario, Canada New line from Winnipeg, Manitoba, to Emerson, Manitoba, Canada
Transcontinental Gas Pipe Line Corporation Houston, Texas	375	3–36	Main line loops, laterals, extensions to system
Trans-Western Pipe Line Company Los Angeles, California	775		Four Corners area to point in California
United Gas Pipe Line Company Shreveport, Louisiana	202	30	Loops from southeast Louisiana to Mobile, Alabama



At the Operator's Command...

W-K-M

Controlled Force Seating

The operator has complete control of the sealing action of W-K-M Parallel Expanding Gate Valves. Sealing is not dependent on either the line pressure or on stress wedging the gate in the valve.

When the W-K-M Valve gate unit reaches the full open or closed position, the torque applied by the operator through the stem forces the gate and segment to expand against the seats to form a perfect seal, upstream and downstream. CONTROLLED FORCE SEATING is completely independent of outside factors. Neither high nor low pressure nor line pressure fluctuation has any effect on the seal of W-K-M Valves.

When the valve is being opened or closed the CONTROLLED FORCE SEATING action is released and the gate unit is held in a collapsed position. This provides a slight clearance between the faces of the gate and the seating rings, allowing the gate to move freely.

Through-Conduit • Pressure Seal Bonnet • Enclosed Packing Gland • Superfinished Stems • Full Repair While Installed • Working Pressures to 2,000 lbs. WOG • Sizes 2" through 30".

W-K-M
DIVISION OF qcf INDUSTRIES INCORPORATED

PLANT: MISSOURI CITY, TEXAS
MAILING ADDRESS: P. O. BOX 2117, HOUSTON, TEXAS

W-K-M is a registered trademark of QCF Industries, Incorporated
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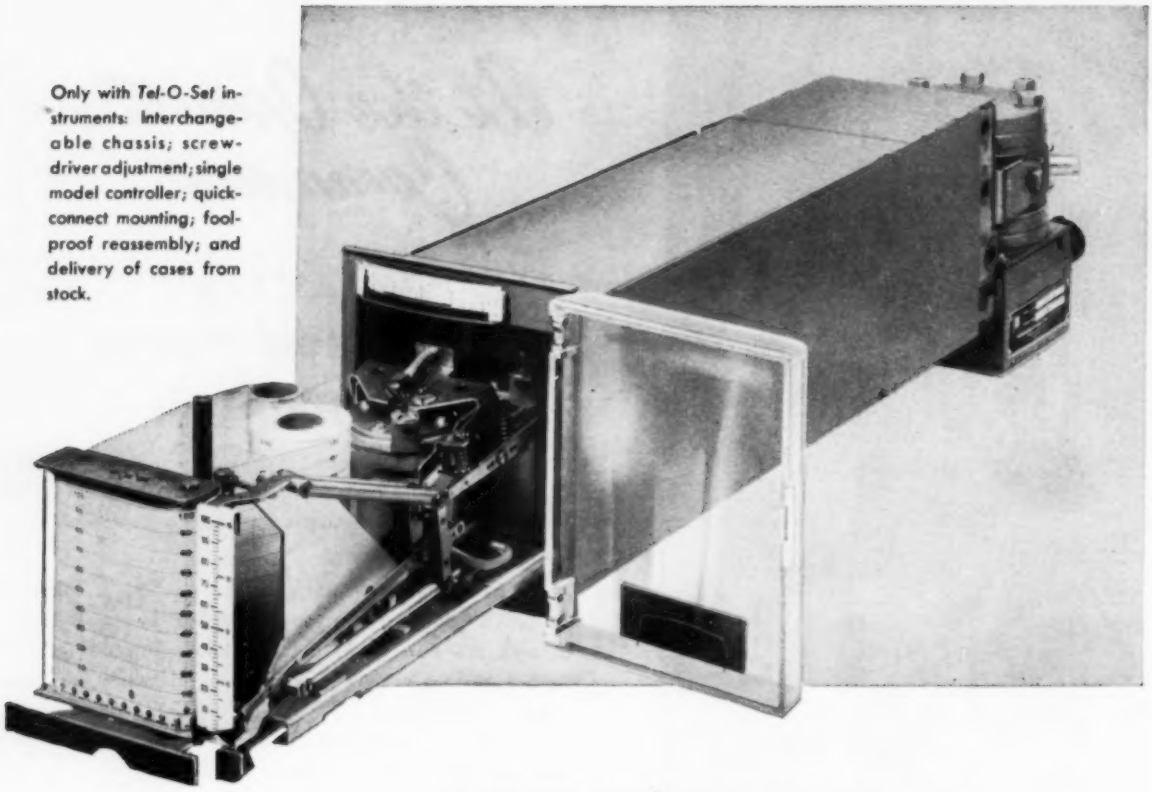
For design and operating features, sizes, pressures and complete dimensions, write Dept. G-3 for W-K-M Through-Conduit Gate Valve Catalog 300.

5716

MANUFACTURERS OF W-K-M GATE VALVES QCF LUBRICATED PLUG VALVES
KEY-KAST ALLOY STEEL PIPING FITTINGS KEY RETURN BENDS AND FITTINGS

Only with *Tel-O-Set* instruments: Interchangeable chassis; screwdriver adjustment; single model controller; quick-connect mounting; foolproof reassembly; and delivery of cases from stock.



you save in many ways . . .

with HONEYWELL TEL-O-SET* Miniature Instruments

New, improved *Tel-O-Set* miniature pneumatic instruments give you across-the-board savings in downtime . . . maintenance costs . . . spare parts stocking . . . personnel training.

Here are some of the reasons for *Tel-O-Set* versatility and economy: You can change a recorder to an indicator or vice versa without interrupting control, simply by pulling out one chassis and sliding another in place. All parts can be inspected during operation, without process interruption. The pneumatic assembly, consisting of a regulator and switches, can be removed from the rear of the case *without disturbing electrical connections.*

Controllers have quick-connect switch permitting removal while process remains on manual control. All instruments are installed and serviced with utmost simplicity.

For complete information on *Tel-O-Set* instruments, write for Catalog C-1001-1, or phone your nearby Honeywell sales engineer. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

*Trademark of Minneapolis-Honeywell Regulator Co.

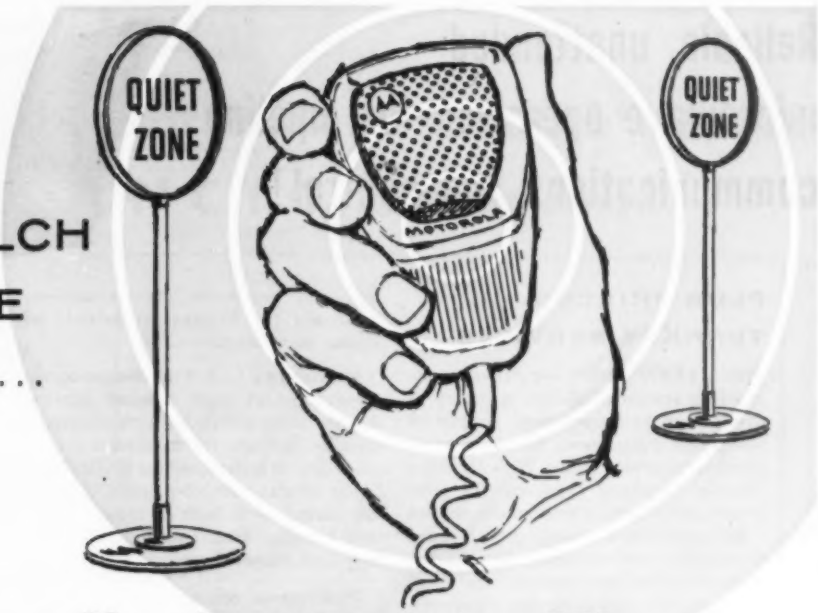
MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

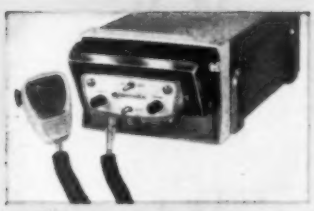
First in Controls

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

NEW
MOTOROLA
DUAL-SQUELCH
PRIVATE-LINE
2-WAY RADIO...



silences all channel traffic except your own messages



POWER

PRIVATE-LINE radiophone is now available in T-POWER (shown above), which features a completely transistorized power supply, as well as TWIN-V radio with 6/12 volt operation.

Get the complete facts about this startling new type of 2-way radio. Write today for these 2 new folders on PRIVATE-LINE radiophone.

Now, with the new Dual-Squelch PRIVATE-LINE radio, you get all the benefits of improved PRIVATE-LINE operation . . . *plus* easy integration for mixed fleets and monitor-before-transmit.

Because PRIVATE-LINE radio is quiet except when receiving a call from another radio in your own system, you eliminate all the "channel chatter." It's much like having the frequency all to yourself. You benefit by reducing the number of missed or misunderstood messages . . . operator fatigue is reduced . . . overall efficiency is increased.

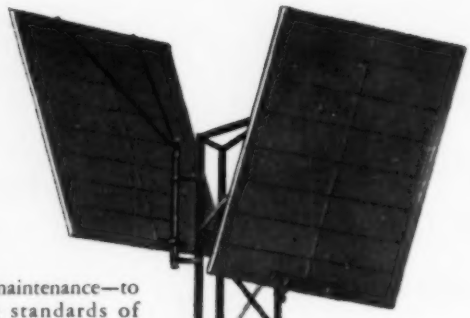
Dual-Squelch PRIVATE-LINE radio gives you these basic features . . . and more. Now you can make a gradual changeover to PRIVATE-LINE operation. During the transition period, your messages can be received by both Motorola conventional and PRIVATE-LINE radios. No longer is it necessary to make the complete changeover to PRIVATE-LINE operation at the same time. And with the new Dual-Squelch operation, you can have manual selection or optional automatic monitoring of the channel before transmitting.

Before you select your 2-way radio, you'll want to investigate Motorola Dual-Squelch PRIVATE-LINE radio.

MOTOROLA PRIVATE-LINE RADIOPHONE

MOTOROLA Communications & Electronics, Inc., A Subsidiary of Motorola, Inc., 4501 Augusta Boulevard, Chicago 51, Illinois

Reliable, unattended microwave operation for pipeline communications and control!



PLUS PHILCO'S TURNKEY SERVICES

Philco CLR-9 microwave delivers outstanding system reliability, economy of installation and operation, simplified equipment maintenance for dependable pipeline communications. With 240 voice channel baseband capacity—for telephone, telemetering and remote control—and capability for handling high-speed computer data transmission—Philco microwave fills both immediate and long-range requirements of modern pipeliners.

Philco's complete turnkey service includes—*site surveys* by competent survey engineers experienced in field techniques; *system planning* by Philco's systems engineers who design your complete communications system; *installation* of your microwave system by Philco field engineers—including erection of towers and shelters; and, Philco field engineers are available for *field service*—periodic inspection and preventive maintenance—to maintain the highest standards of system performance.

Philco's new CLR-9 microwave equipment provides high channel density, duplex communications with integrated standby facilities for maximum system reliability. It is designed for quick installation in standard relay racks . . . and engineered with built-in metering and test facilities plus plug-in chassis for easy field maintenance.

Performance reliability is sharply increased in the new CLR-9 by the use of tubeless power supplies—new semiconductor rectifiers replace tubes. The use of printed wiring panels increases circuit stability—and complete plug-in chassis may be quickly removed by maintenance personnel (permits efficient, centralized depot maintenance). Klystrons in the new CLR-9 are cooled by convection . . . the use of compact heat sinks eliminates the need for bulky blowers. .

At Philco, opportunities are unlimited in electronic and mechanical research and engineering • Look ahead . . . and you'll choose Philco.

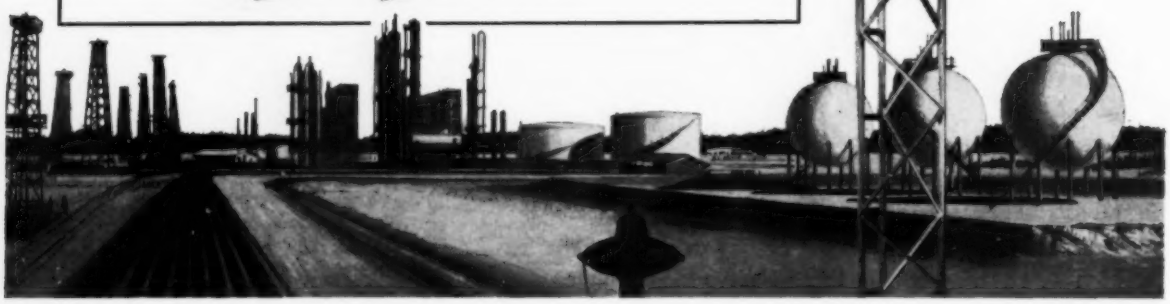
NEW PHILCO CLR-9 MICROWAVE STATION

The CLR-9 terminal consists of wave-guide assemblies, master control, tubeless power supplies and plug-in chassis for IF assembly, baseband drop, modulator, reflector control and servo.

Rugged printed wiring panels increase circuit stability and simplify maintenance.

Heavy-duty, tubeless power supplies increase reliability by employing semiconductor rectifiers—assures maximum reliability and minimum maintenance.

Heat sinks cool the Klystrons by convection—gear drive assembly permits precise Klystron tuning.



PHILCO®

Government & Industrial Division

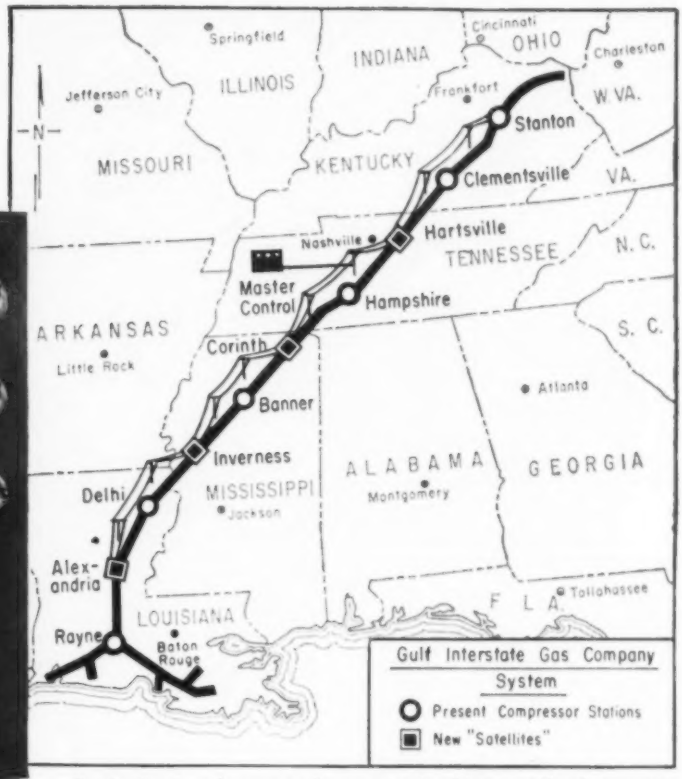
4718 Wissahickon Ave., Philadelphia 44, Pa.

In Canada: Philco Corporation of Canada Limited, Don Mills, Ontario

PIPELINE AUTOMATION PAYS!

Gulf Interstate's unattended "satellite" station shows how UNION C.T.C. lowers costs with safety and reliability.

UNION Control Panel at Stanton, Ky.



Construction is under way on four new engine-driven centrifugal compressor stations. All will be remotely controlled unattended "satellites." Operations will be directed from a UNION master control panel near the center of the system.

The Gulf Interstate Gas Company's "satellite" station at Stanton, Kentucky provides most economical and safe operation, according to Mr. R. Lo Chiano, assistant chief engineer at Gulf Interstate.

The Stanton station is remotely controlled from Clementsville, Ky., 90 miles away, through a UNION Centralized Transport Control System and has been on completely *unattended* operation since June 1956. This system is unique because it provides remote control and indications for a turbocharged engine driving a centrifugal gas compressor . . . the first installation of its kind. Large savings result because the operator at the master station can change the set point on the discharge pressure controller and start and stop the engine at Stanton.

Another important saving is obtained because the UNION C.T.C. System uses only one leased line circuit to transmit all the controls, indications and telemetering data. The control system used permits the use of the lowest-cost circuit. This installation was "custom engineered" using standard UNION components to meet the particular requirements.

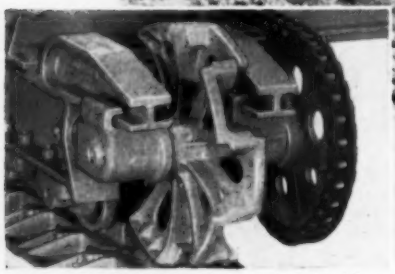
The unattended station is definitely successful. There have been no false shut-downs that were not man made. With this in mind, future stations are being patterned after the one at Stanton.

Write for further information on UNION C.T.C. for all types of pipelines, gathering systems or tank farms. Ask for Bulletin 1052.

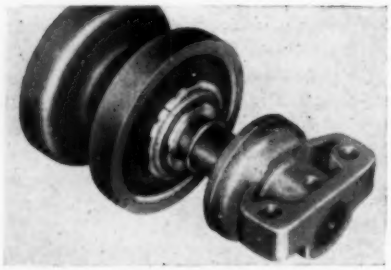
UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

built for pipeline work

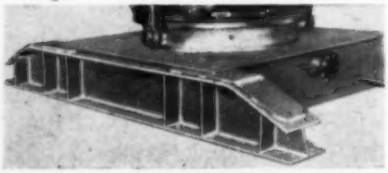
THERE'S AN **INSLEY** WORKING NEAR YOU



Crawler End Tumblers equipped with bronze seal rings.



Crawler Rollers protected by bronze seal rings and by neoprene rubber O-rings.



Carbody . . . wide and heavy to withstand stress. Three-piece removable bottom cover plate. Hinged center panel.

The challenge of pipeline work has been a good test for the ruggedness and dependability of Insley excavators and cranes. Insley's widespread popularity and leadership in the pipeline construction field prove Insley's capability in meeting this challenge.

The Insley Pipeliner is *built* for pipeline work. It is a high performance machine with the durability that the tough jobs demand.

Heavy Duty Hoe Attachment · Box-Type Jackframe · Optional: Two-Speed Travel · Tractor Type Crawlers · Brake Type Cab Lock · Independent Boom Hoist

INSLEY MANUFACTURING CORPORATION
GENERAL OFFICES—INDIANAPOLIS 6, IND.
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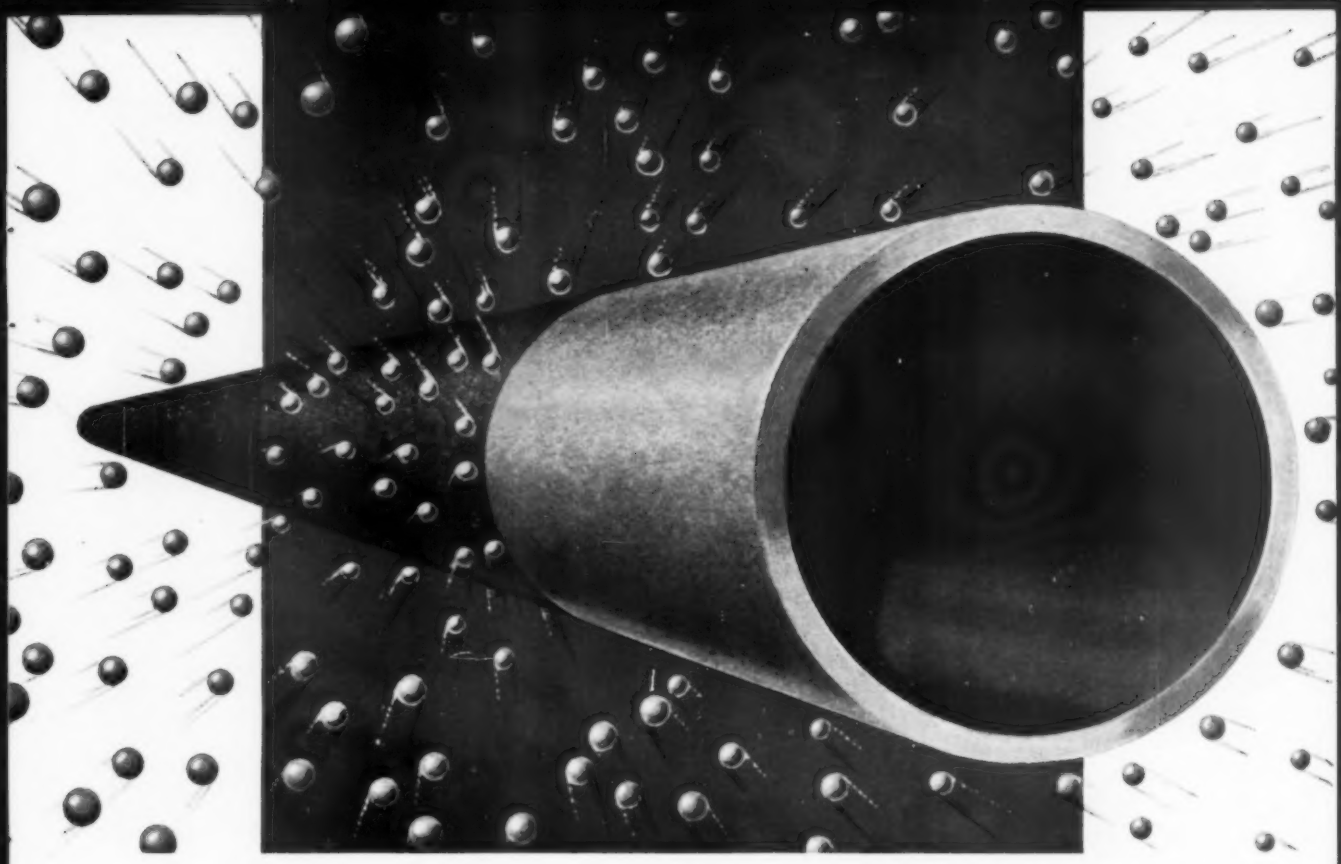

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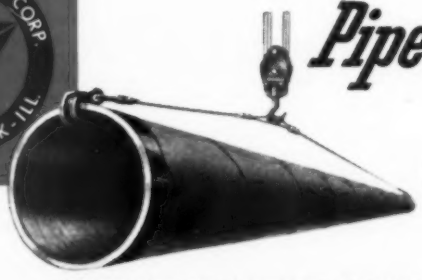

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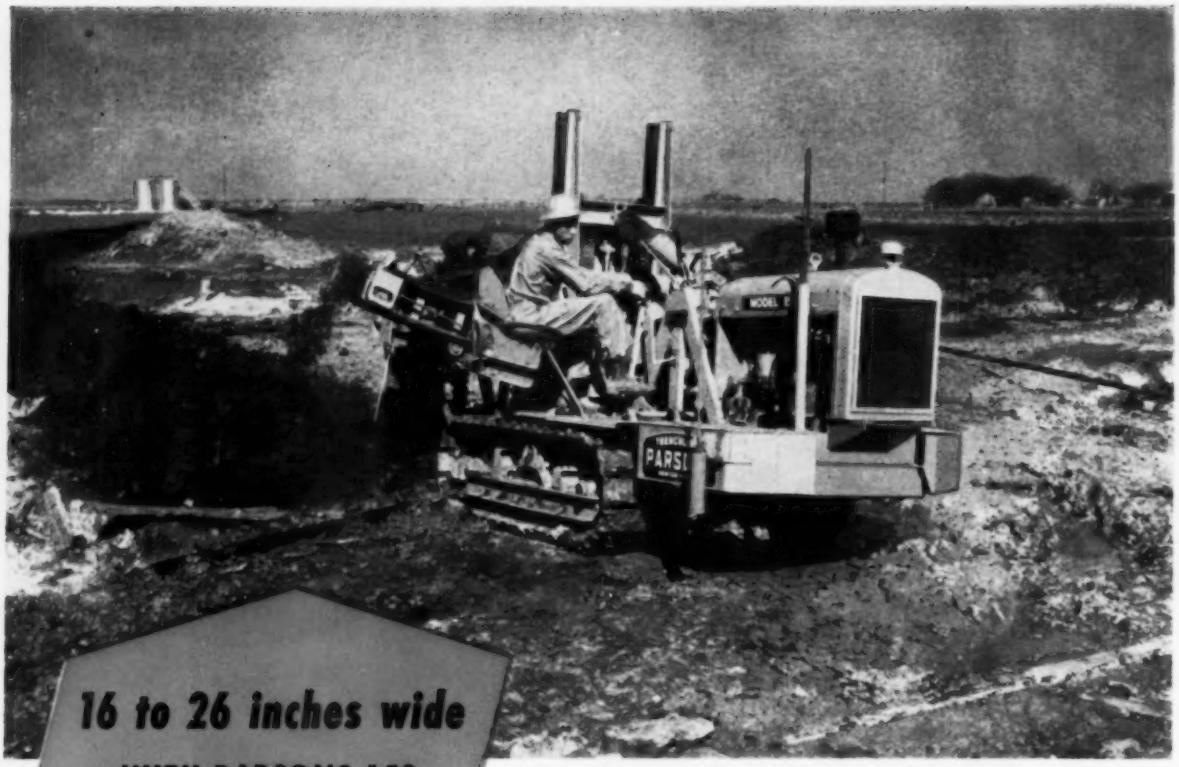

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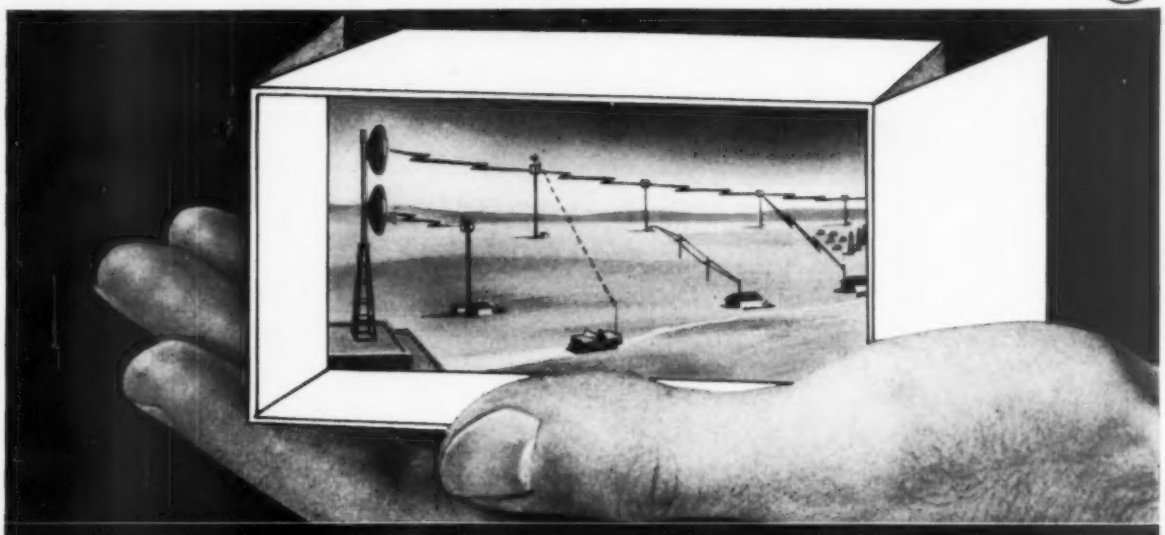

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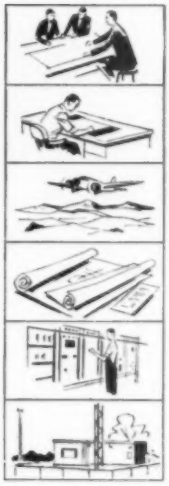

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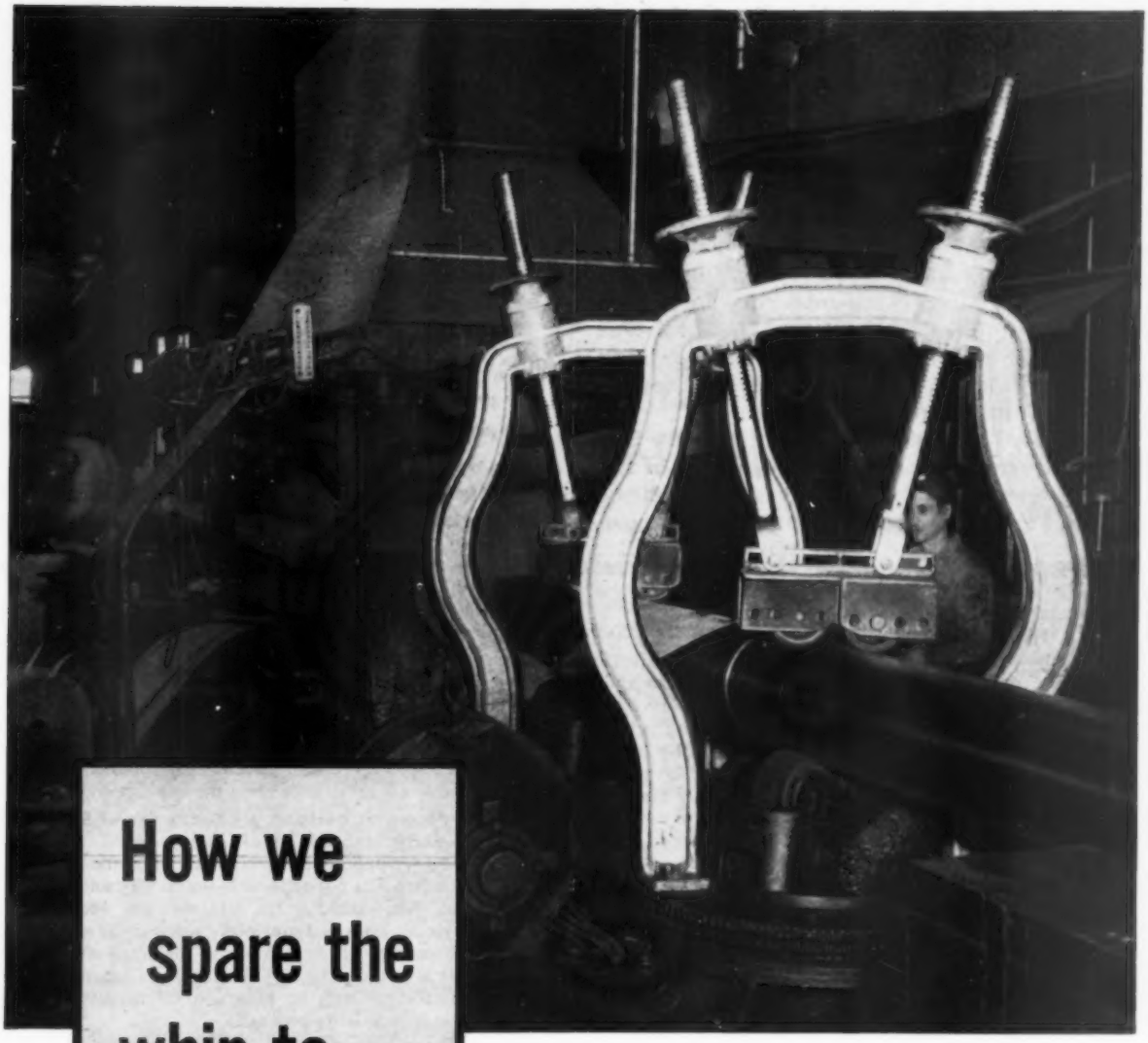

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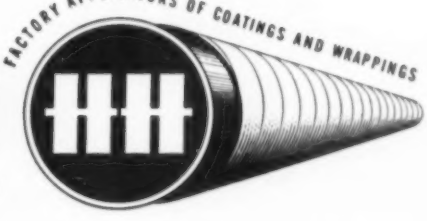


How Blue Are Those Memphis Blues?

For nearly 20 years, pipeline companies have instituted rate increases under Section 4 of the Natural Gas Act. But the Memphis Case decision nullifies this avenue of rate increases without customer consent.

This means the companies may find it necessary to turn to Section 5 of the Natural Gas Act. How this can be done is related by noted public utility financial analyst, Willard F. Stanley. In his opinion —

- **Section 5 can be used effectively.**
- **Procedure under Section 5 can be stepped up to be as speedy as the presently used Section 4 procedures.**
- **If the Supreme Court upholds the Memphis decision, there will be some immense problems related to refunds.**

What do you mean by "Memphis Blues?"

The natural gas pipeline industry is singing the blues these days, the *"Memphis Blues,"* as Chairman Kuykendall of the Federal Power Commission aptly termed them in his January 3 talk to the New York Society of Security Analysts. The decision of the U. S. Circuit Court in the *Memphis* case dropped a bombshell into a thriving industry. This case, following the *Mobile* and *Sierra* cases, decided by the U. S. Supreme Court, has placed the pipeline companies in a highly questionable position, particularly as concerns the necessity of refunding vast amounts of rate increases collected in the past.

But just how "blue" are these "Memphis Blues?" Is pessimism being overdone? Let's try to analyze the impact of this decision and the available remedies and see whether a few beams of light can't be found to pierce the thick gloom surrounding this subject.

Is the outlook dark?

The situation is certainly serious, but it may not prove nearly as hopeless as many have been led to believe by garbled newspaper stories. In particular, there seems sound reason for hope of establishing reasonably rapid procedure for future rate increases.

The gas pipeline industry and the markets in the securities of the pipeline companies have had to withstand adverse impact of numerous newspaper stories which, ignorantly, but no doubt innocently, distorted the effect of the *Memphis* decision. For example, it has been stated on several occasions in the press that the *Memphis* decision held that rates cannot be increased without consent of all customers affected. Of course the *Memphis* decision held nothing of the kind.

What did the court mean?

What the court did hold was that approval of all customers is needed **unless the FPC, after investigation, acts to increase rates under Section 5 of the Natural Gas Act.**

What has been the procedure in the past?

In the past, procedure has been for companies wishing rate increases to apply for them to FPC under Section 4 of the Act. FPC would then either (1) deny the increase in whole or part, or (2) permit it to become collectible, the company bonding 10 percent of the increase for refund to customers in the event the Commission should finally determine that the increase should be denied or reduced.

During this interim period the increased rates were collectible but treated as in "suspension" until the final determination of the Commission was made. In most cases, the effect of this procedure was that the rate increase would become collectible six months or something less from date of filing the application.

Then the *Memphis* decision precludes use of Section 4 without specific consent of all customers?

The *Memphis* decision concluded that the Section 4 procedure was not applicable unless all customers affected had agreed to the increase. The *Mobile* and *Sierra* decisions had previously reached the same conclusion, but only in relation to the small number of cases where contracts with customers specified fixed rates for gas with no provision for revision thereof through regulatory processes.

The serious aspect of the *Memphis* case is that it extends this doctrine to include the numerous cases where gas prices under the contracts with consumers were subject to increase by regulation. This has the effect of increasing the scope of the decision from a small minority of cases to practically all rate increases in the industry.

Thus the *Memphis* decision transfers the procedure for rate increases from Section 4 of the Natural Gas Act to Section 5 of the Act. Even in those cases where the newspaper stories correctly reported the effect of the Memphis decision by mentioning the right to increase rates thereunder pursuant to Section 5 of the Act, they created another source of alarm by reporting, in a number of cases, that it was expected the Section 5 procedure would consume a long period of time, reference being made to "years" and even "many years," etc.

Hasn't Section 5 always produced lengthy cases?

It is true that Section 5 procedure in the past has been protracted, but that has been because rate increases have uniformly been handled by FPC under Section 4, and only proposed *rate reductions* have been processed under Section 5. Naturally, in these cases, there was no pressure from the companies for prompt decision. In fact, final determination could be

Newspaper reports have been extremely pessimistic, but the situation is not hopeless; in fact, there is every reason for the pipeline industry to be optimistic – for there are sound reasons that reasonably rapid procedures can be established for future rate increases.

Willard F. Stanley, formerly financial vice president of Southwestern Public Service Company, is president of Corporate Services, Inc. of New York City. He is a member of the Controllers Institute of America and the New York Society of Security Analysts. He is a frequent contributor of articles on financial management to leading business publications.

expected to be considerably delayed by various filings by the companies of additional facts or arguments.

Could you outline the specific problems?

Problems confronting the pipeline companies and investors in their securities by reason of the *Memphis* decision are:

1. What is likely to be the ultimate result thereof, and
2. Assuming the most adverse legal outcome (from the standpoint of the companies and their investors, what is likely to be the impact upon (a) market values of the common stocks of the pipeline companies (and of their other securities), and (b) how will such an adverse outcome affect the ability of the companies to finance necessary expansion?

These problems seem to divide themselves, logically, into two basic sections, viz:

1. The ultimate impact of the *Memphis* decision on the ability of the companies to obtain pending and future rate increases; and
2. The ultimate impact of the decision on the pipeline companies with respect to their obligation to refund to consumers the amounts of rate increases already collected.

What are some solutions?

Considering (1) mentioned above, it appears that there are a number of solutions of the problems, as follows:

A. Granting by the U. S. Supreme Court of a *writ of certiorari* to review the *Memphis* decision, followed by a reversal of that decision by the U. S. Supreme Court, thus reverting the legal status of the matter to that following the *Mobile* and *Sierra* decisions. In this event the rate increase procedure should continue under Section 4 in the great majority of cases and the impact on the natural gas pipeline industry would seem to be negligible. The U. S. Solicitor General, with the cooperation of the FPC has applied to the U. S. Supreme Court for a *writ of certiorari*. Chairman Kuykendall, in his January 3 address, said he expected the court to grant the writ and to decide the case during the court's present term. It seems reasonable to anticipate, in view of the importance and immediacy of the issues, the court will act with a minimum of delay.*

B. Enactment by Congress of amendments to the Natural Gas Act clarifying the provisions of Section 4 to permit following the previous FPC procedure on rate increases, or providing for some revised form of such procedure that would be equitable and expeditious. Congress is in session and FPC has indicated that it would support such legislation and request its prompt enactment. In view of the recognized need for expansion of pipeline systems, it seems unlikely such amendments would be strongly opposed. Formalities of legislative procedure sometimes prove obstacles to prompt Congressional action, although these difficulties are usually surmountable where both parties are in agreement. Subject to the procedural aspect, it seems reasonable to hope that in the absence of strong opposition the legislation may become effective in the not distant future.

C. Speeding up the granting of rate increases under Section 5, following FPC investigation and hearings, Chairman Kuykendall, in his January 3 address, did not indicate any minimum time for clearing rate increases under this section, but he did say "I suspect that we may find that a rate case under Section 5 can be processed in much shorter time than was ever thought possible." It seems likely that the tempo of FPC investigations can be stepped up, with company cooperation, so that not too long after the lapse of the six months period usually intervening between rate applications under Section 4 and permission for such rate increases to be collected, the investigation could be completed and the rate increase become effective under Section 5.

Won't Section 5 still make for lengthy hearings?

It has been the custom of pipeline companies applying for rate increases under Section 4 to anticipate the usual six months delay in collection by reflecting in their applications the increases in operating costs reasonably estimated to occur within this period.

In other words, the request for rate increases is based upon the situation as it would exist six months

*On February 3, 1958, the U. S. Supreme Court granted a Writ of Certiorari in the Memphis case, agreeing to review the decision. It now seems probable that a final decision, after appropriate hearing, will be handed down not later than June, 1958, when the present term of the court will end.

. . . delay under Section 5 will shrink in actual practice . . .

after the application was filed. There seems to be no reason why such anticipated changes in costs could not legitimately and practically be carried forward to comprise a period longer than six months, perhaps up to a maximum of a year.

The relative determinability of pipeline costs, chief among which is the cost of gas (readily determinable for any period by reference to the contracts with producers) makes such forward looking feasible in the case of the pipeline industry. The views expressed in this paragraph were suggested by the chief executive of a large retail gas distribution company and therefore seem deserving of serious consideration.

Could it be just as speedy as Section 4 is now?

The "many years" of delay in making rate increases effective under Section 5, so dismally reported in the newspaper stories, will probably shrink in actual practice to something much less disturbing.

Considering the intensive efforts that pipelines will make to supply all needed information to support desired increases, expressed intention of the FPC chairman to cooperate in obtaining a decision as soon as feasible, and the improbability of serious opposition to such rate increases (particularly where it is evident they are needed to attract financing necessary for expansion to meet increasing gas needs of the consumers) it doesn't seem unlikely that Commission decisions under Section 5 may be forthcoming within a year after initiation of the case, and perhaps not too far beyond the six months period that has been more or less customary for initiation of collection of increased rates in the past under Section 4.

Accordingly, there seems little reason for present or prospective investors in gas pipeline securities to be seriously disturbed over the impact of the *Memphis* decision on the ability of the industry to obtain justified rate increases in the future with reasonable promptness.

Either the *Memphis* decision will be reversed, or remedial legislation enacted, or, failing both of these remedies, it's probable that procedures will be developed for reasonably prompt action by the FPC to increase rates under Section 5.

Can Section 4 still be used?

Until final decision is reached in the litigation, FPC has made it clear that it intends to follow previous procedure and permit rate increases to be collected under Section 4. Two such rate increases have been so permitted since the *Memphis* decision was handed down. In his address to the analysts, Chairman Kuykendall said that the commission did not recognize the *Memphis* decision as "final or binding in any manner at this time," although he stated the Commission had not ignored the possibility that the decision may become so and had accordingly provided that the affected pipeline companies must furnish a bond for 100 percent of the rate increase to insure refund to customers should this prove necessary.

It is to be hoped that the Commission may find it desirable and feasible (both legally and practically) to enter orders under Section 5 as soon as possible after completing their investigations, in all rate cases that they act upon in the interim pending final decision in the *Memphis* litigation.

In that event the Commission would act dually; first, to permit collection of the rate increase, under bond, pursuant to Section 4, and second, to authorize a similar increase under the Section 5 procedure.

In the event that the U. S. Supreme Court supports the *Memphis* decision, this should limit the period when refund of the increase collected might have to be refunded to the interim between initiation of collection and the entry of the Commission's order under Section 5. Otherwise, in the two recent cases, and in future cases, refunds might, under such circumstances, become necessary not only for the above described interim period but for a subsequent period extending at least to the time of the final decision in the litigation.

What about refunds?

Referring to (2) above, as to the matter of possible refunds of rate increases that have been collected in the past under the Section 4 procedure, we are confronted with a problem somewhat more difficult of solution.

Chairman Kuykendall, in his January 3 talk, stated the total amount of rate increases presently being collected under Section 4 procedure subject to possible refund was about $217,000,000 per year and that the total amount subject to refund — for the total time that all suspended rates had been in effect — was approximately the same amount.

But he pointed out also that "it may rather logically be contended that all rate increases obtained at any time since the passage of the Natural Gas Act, by unilateral rate filings under Section 4, are a nullity and must be refunded, with the possible exception of those cases which were settled by agreement of all parties and with approval of the Commission."

This last sentence opens a truly wide vista of refund obligations. No amount was mentioned in relation to these possible additional refunds and it is difficult to hazard a guess what they might come to, but the assumption is inescapable that this amount must be of substantial magnitude and probably far exceeds the amounts involved in present rate suspension.

What, then, is likely to be the impact on the industry if the adverse decision is upheld and such refunds become necessary? Can Congress help with new legislation?

Remedial amendatory legislation by Congress can be of no help here, since it would not operate retroactively to validate previous rate increases. Nor can the speeding up of rate increase procedure under Section 5 give relief as to refund obligations since it relates to future, and not past rate increases. Therefore, the sole remedy seems to lie in the area of legalities; first, to obtain a reversal of the Circuit Court decision and, failing this, to obtain some other form of legal relief.

What form might such other relief take?

In his January 3 address, Chairman Kuykendall mentioned the possibility of invoking constitutional provisions prohibiting confiscation of property to protect the pipeline companies affected from the requirement to make refunds that would bring about bankruptcy and thus prevent them from rendering necessary service to the public. Even though impact of the refunds fell short of causing bankruptcy, credit might be affected so adversely as to prevent financing necessary to expand and render necessary service.

Mr. Kuykendall also suggested that a pipeline company might be entitled to have "a *quantum mercuit* recovery for gas delivered," i.e., to receive a fair price for the gas that would constitute, in effect, a rate increase. It appears that none of these legal approaches were discussed or considered in the *Memphis* decision.

What possibility is there that some pipeline companies may become bankrupt?

Mr. Kuykendall concluded his remarks on the re-

fund aspect of the matter by saying, "I find it difficult to believe that the *Memphis* decision will ultimately cause the bankruptcy of an important part of the natural gas pipeline industry and thereby prevent the public from getting the natural gas service it needs and deserves." The situation is quite unusual in that the apparent conflict between buyers and sellers of the gas as to the price of the product may not be a strenuous one. This is true because these buyers have a keen interest in the availability of sufficient gas to meet their needs and are therefore willing to pay an increased price for gas where this seems necessary to attract capital to make the needed quantity of gas available.

So, there remains the further possibility that if legal remedies fail, settlements of refund claims may be worked out on bases that will not be sufficiently burdensome to affect financibility of pipeline expansion.

The amounts so involved might well be such as the pipeline company could afford to pay without excessive burden on earnings or assets, and the payments could probably be scheduled so as not to interfere with needed expansion and normal operations.

Impact of refunds may also be cushioned, in some cases, as pointed out by Chairman Kuykendall in his address, by the right of the pipeline company to receive refunds from other pipelines from which it purchased gas.

Also, price refunds will automatically entitle the pipelines to appropriate refunds of income taxes for all "open" years in which the tax liability is still subject to adjustment.

It might be worth exploring to see if the possibility of refunds being required with respect to rate increases granted since inception of the Natural Gas Act and no longer in suspension could not be limited to the periods of suspension involved in such increases, by some appropriate present action of FPC designed to make the finalization of these increases in the past effective as increases granted pursuant to Section 5. In other words, determination of FPC finalizing the increases under the Section 4 procedure would, by such action, also become effective as similar rate increases under Section 5.

How do these possible refunds affect investments?

Despite possibilities of relief and the impressive arguments — to the effect that, under circumstances such as these, it is inconceivable that a way cannot be found to work out a conclusion in an amicable and reasonable manner — the threat of possible refund obligations of great magnitude will necessarily overhand the industry until some effective remedy is discovered. The importance of this threat will naturally vary with each pipeline company according to the amounts of Section 4 refunds that may be involved, considering both rate increases presently in suspension and increases finalized prior to the *Memphis* decision.

Impact on the common stock prices, as well as future financibility of the various companies may, in the future, vary according to the maximum and minimum amounts that the investment fraternity and investors estimate each pipeline may be required to refund.

How has the market reacted to the *Memphis* decision?

Th old adage as to the "proof of the pudding" seems applicable in evaluating the impact of the *Memphis* case on the pipeline industry and its securities. So let's see what American investors and their advisers in the investment fraternity have done (up to January 26) to reflect such impact in the prices of pipeline common stock equities.

For this purpose the table above compares the average price of several pipeline company stocks at three

. . . a way must be found to grant warranted rate increases. . . without unreasonable delay . . .

dates; viz., October 24, 1957, (four months ago and not long before the *Memphis* decision); at December 31, 1957, (when the *Memphis* decision had been in existence for over a month but was just beginning to receive front-financial page publicity), and, finally, at January 24, 1958.

	10/24/57	12/31/57	1/24/58
Average price of 6 listed pipeline stocks	$33.21	$35.50	$36.81
Average price of 6 unlisted pipeline stocks . . .	24.22	23.02	26.37
Average price of 12 publicly held pipeline stocks . .	35.88	33.74	37.91

Between October 24 and December 31, 1957, the average for the 12 stocks declined 6 percent, but for the subsequent period this average rose 12 percent, which compares with an increase of around 6 percent for the 50 combined stock average of the New York Times for the same period.

For the entire three months, pipeline stocks showed an average increase of 6 percent. The trend in these stocks was fairly consistent in that all but one showed declines during the first period; all of them showed increases in the second, and all but four came out at January 24 ahead of their level three months earlier. This relatively uniform trend seems to indicate the market is not giving very material significance to variations in the amounts of possible refund obligations as between the affected pipeline companies. Perhaps these market valuations don't reflect all the necessary pertinent information and action in stocks of the individual companies and may vary more widely in the future, after the individual maximum possible refunds are known, but to date the market certainly hasn't reflected panic fear as to the outcome of the spending problems.

How would you sum up the impact of the *Memphis* decision?

All responsible parties seem to agree that a way must be found to grant warranted rate increases to pipelines without unreasonable delay and also to avoid affecting the credit of the industry and the attractiveness of its securities sufficiently to interfere with the orderly financing of necessary expansion.

While it cannot be disputed that the *Memphis* case poses serious industry problems, particularly in respect to refunds or previous rate increases, there seems, on the whole, and considering the many "strings to the bow" that appear to be available for possible remedial action, to be justification for a moderately optimistic attitude toward the pipeline business and its securities.

But this is far from warranting an attitude of complacency. All the ingenuity of the industry, the investment fraternity, regulatory bodies, and their respective learned counsel are sorely needed if a favorable legal conclusion is not forthcoming. These efforts are also needed to make the most effective possible presentation of the case to the U. S. Supreme Court if the *writ of certiorari* is granted.

It is far better that all concerned approach the matter in expectation of an unfavorable final court decision and thus stimulate the development of effective alternative solutions, than to proceed on the basis of a fancied security, only to find themselves disappointed in the legal outcome and with no effective alternative solutions for the serious problems involved.

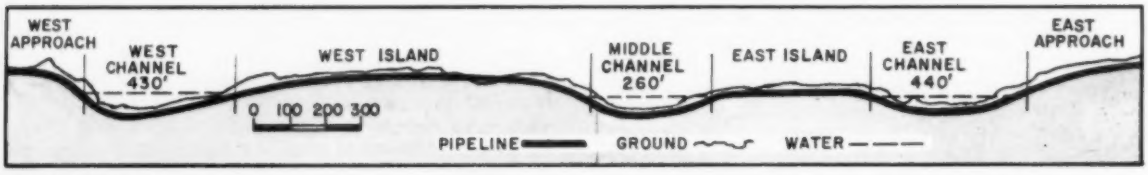
* * *

P 615.371.

This is how the west approach looked before shot hole drilling started. Churn drills on barge are moving in for wet ditch. The sheer rock face had to be graded to a uniform slope into the water.

At a point on the Trans-Canada Pipe Line the Winnipeg River separates into three channels, the flow rate is as great as 18 mph, and terrain is of hard granite, making the . . .

KENORA CROSSING A TOUGH ONE!



Profile of Winnipeg River crossing at Kenora, Ontario, Canada.

Leslie Orr Rowland

THE OPERATING LOOP for the most difficult dual-line water crossing on what will be the longest natural gas pipeline in the world was completed in four months under the triple channel of the Winnipeg River near Kenora, Ontario. This was on the publicly-owned section of the Trans-Canada pipeline, being built by Northern Ontario Pipe Line Crown Corporation under private contracts. When finished next fall it will be leased to Trans-Canada Pipe Lines, Ltd., with an option to purchase over a long term. The second loop of the crossing had been laid, except for one section, a month later at the end of January, but completion was held up by ditching problems of this last water section.

Designed by Kenneth E. Britain, project manager of Trans-Canada, the Winnipeg River crossing was let to Canadian River Construction, Ltd., of Vancouver, an affiliate of Morrison-Kundsen of Boise, Idaho. Vernon Gayheart was construction superintendent and John Pierce rock ditch foreman. W. Woodworth was project manager and J. C. Minyard general superintendent.

Unique feature of the crossing was the division of the river at this point into three separate channels, with extremely fast flow rates varying from 12 to 18 mph. The entire terrain is igneous granite, hardest and most homogeneous rock formation known anywhere in the world, with no fracture planes. The bed of each channel was found to be rough and craggy, with cliffs and ledges.

Each land approach on the outside channels consisted of an overhanging cliff rising sheer out of the water to a height of 200 ft on the west approach and 300 ft on the east approach.

Separating the channels are two islands, both of the same solid granite rock as the rest of the crossing. The east island had one sloping approach on the west side, on the center channel, but the east approach, facing the east channel, rose in a considerable overhanging crag to a vertical height of more than 100 ft. The west island had a 200-ft cliff on the east side, facing the center channel, and a more gradual approach on the west side, facing the west channel.

All approaches had to be graded down for a gradual even slope into the water, including 500 ft for each mainland approach. Right-of-way had to be cleared for 100 ft in width to accommodate dual 30-in. lines. Total length of the crossing was 3200 ft for each line, or 6400 ft of pipe altogether from bank to bank. Tie-in at each side was made just above the water line.

Average depth of water was 35 ft

during the job, and the side walls of the channels were almost vertical to the channel bed, due to the nature of the terrain. This is normal ground structure for the Precambrian Shield, but it was the first time in Canadian pipelining history that such a long crossing had been laid in such deep water in this kind of ground.

Each line in the east channel required 440 ft of pipe, the center channel 260 ft, and the west channel 430 ft. At two points on the islands the contractor was able to find enough level space to grade an extra 100 ft in width to provide staging areas to make up the pipe sections.

General Design

The crossing was designed to conform to the requirements of the Dominion Department of Public Works for pipelines laid under navigable rivers, providing for a minimum of three feet of cover in the solid rock. Actually, because of the very heavy marine traffic on the river in the summer vacation season in this popular resort area, the ditch was drilled to a depth of six to eight feet below the river bed so there would be ample margin of safety. This was also a precaution against silting up during the pulling of the various sections, as the river carries a heavy volume of effluent from a large pulp and paper mill in the industrial section of the town of Kenora, one mile upstream from the crossing site.

Pipe was supplied in 0.500-in. wall thickness. API specification 5LX52. It was coated with hot coal-tar primer enamel and asphalt coating. Inner wrap was of glass fiber and the outer wrap of impregnated asbestos felt. Asphaltic-type rockshield was taped on with steel bands as a reinforcing outer wrap, and wood lath lagging was wired on between the reinforced concrete split-collar river weights, which weighed 6200 lb to each pair.

The two ditches were drilled to sufficient depth to provide 30 in. of cover in the land areas, and the lines were laid out 50 ft apart.

Plan of construction as set up by the contractor was to drill the north line ditch first, so there would be a reasonable chance of tying-in this loop before any risk of shut down due to winter weather. Both wet ditches had to be drilled in each channel, however, before the first string could be pulled, because of the risk of damage if ditch was shot with pipe in the other ditch.

The east approach and the east side of the east island were drilled first, of the dry ditch, while the east channel and the west channel were drilled concurrently with churn drills mounted on welded steel pontoon barges. On each land location one twin drill was set up on the sideboom of a pipelayer. Working space on the rugged terrain was only enough for one unit on each side.

Looking east across east island from west island shows comparative height of land areas. This pipelayer is holding an airdrill by means of a winch line.

The work program was laid out so that three twin units were employed continuously, moving progressively across the job from the east approach to the west approach. To start with, one unit was on the east approach, one on the east side of the east island, and one on the west side of the east island. One extra unit, a light-weight self-tracked drill, was anchored by another pipelayer with a winch line on the steep east face of the west island. A 600 cu ft compressor was used to supply air for each set of drills.

Access to the entire job was exclusively by water, including the land approaches, for the first few weeks, as main line construction did not reach this point until half-way through the crossing job and the right-of-way was impassable. Water transportation was the only means of access to most of the job at all times. Almost every available rental boat in the area was used to carry men and supplies to floating wooden docks, which were anchored by wire lines at some of the approaches, or to rough rock landing stages at other points. Nearest public dock was one mile downstream, and this was used as the embarkation point for the entire fleet, including the big barges that carried pipe across to the islands.

Drilling and Shooting

The spread moved in on August 18, 1957, and in the first week drilled and fired 1000 shot holes and moved 3000 yards of rock. In this time the first 26 ft in vertical depth of the rock cliff on the east land approach had been drilled off and cleared away. Several bulldozers were kept busy moving shot rock and a backhoe and dragline were used to clam out the ditch after shooting. The backhoe had to be anchored by a pipelayer and a winch line on the steep slope.

Tungsten carbide drilling bits were used throughout. Shot holes were drilled on four-foot centers for the land ditch, staggered in parallel lines across the width of the ditch. Shooting was done with primer cord and 75 percent forcite. The rock was found to shoot satisfactorily with this high-powered dynamite, and most of it broke up into fairly small pieces in spite of the absence of any fractures to help it. Every slope had to be cleared completely down to grade, so no fill remained on any part of the right-of-way. Dynamite all had to be transported by boat, in small quantities, and was carried from the landing stages by human "mule trains" up the slope to the stockpiles.

The wet ditch was handled by three drilling barges, each carrying two percussion churn drills with 18-in. strokes. One was placed in the east channel and two in the steeper and deeper west channel to start with, and two finished off in the center channel.

Shot holes were all drilled to a minimum depth of 14 ft into the river bed to ensure enough break-up on the first shot to guarantee the minimum depth of finished ditch. Total depth of holes below the water surface was as much as 56 ft because of substantial variations in the depth of water from the beginning to the end of each working week at the pulp mill. The mill shut down for two days at the weekend so that the water was normally shallowest on Monday and then increased in depth and flow through the week to Friday evening. The barge-mounted drills were steam-powered, with wood-fired boilers. The dragline was mounted on a barge to clean out the center portion of each channel.

Shot holes in the river bed were drilled on six-foot centers, cased with

Front tractor holds a backhoe on a winch line while cleaning out ditch that has been shot.

6-in. well casing, loaded with 75 percent forcite, the casing pulled and the holes shot simultaneously with Primacord in as large a group as feasible.

Shooting was a slow job, as the barges had to be moved away to a safe distance of half a mile or more with tug boats and moved back again after the shot. The guy wires that anchored them to the shore had to be cast off each time and attached again.

Pipe Make-Up

Grading on the east island had to be completed before any pipe could be strung, because of the narrow working space and the risk of damage to pipe from ditch shooting with pipe on the staging area. Weather remained exceptionally good, with higher temperature and much less snow than normal for the Kenora region. There was no snow at all until the second week in November and it never reached a depth of more than two or three inches up to Christmas, when the last pull had been completed. Temperature dropped considerably below zero on several occasions, but only for a day or two at a time, and the mean temperature from mid-October to mid-December was around 20 F.

Pipe had to be heated for welding, and cold-weather coating was used. Make-up proceeded satisfactorily and was almost completed by November 15. River weights were attached on 10-ft centers, bolted, and banded with steel tapes.

The first water crossing section was pulled on October 22, comprising the 440 ft under the east channel. It was made up in four sections, and as each section was walked in the next section was welded on the east slope of the east island. Weighing approximately 1000 lb per ft with river weights in place, each section was carried down the slope by five pipelayers and walked into the water, while two anchor-tractors pulled with a medium-size cable from the east land approach. This approach section was already in place, with valves set, and the tie-ins were made immediately.

At this time the ditching had been completed under the east channel, dry ditch was finished over the east approach and both islands and up the north side of the west approach. Wet ditch was proceeding slowly and painfully in the very hard west channel with two barges, and ditching was started in the center channel with one barge. The west channel presented special problems, as some hard-core strata were so tough that shot holes took up to 48 hours to drill.

Between then and November 22 the lines were laid across the islands and up the west approach, where the dry ditch on the south side was the last of the land ditch to be completed. West channel ditching for the north (operating) loop was completed the following week and this line was pulled in sub-zero weather. The center channel was completed and both the lines pulled and tied in by December 20 so that gas could be delivered to Kenora. Four sections were used for the west channel loop and three each in the center channel.

Backfilling was largely completed, as the lack of snow made this a feasible operation, but clean-up was left to be finished next summer with a partial crew.

The north loop, which is carrying the gas, was pigged and purged and tested out between December 20 and the end of December, but the spare south loop still had a gap for the west channel at the end of January, as the ditch had to be re-shot for full depth. Further delay was encountered in the last week of January when it was discovered that the strong 18 mph current was washing backfill into the ditch. At that time it was calculated that the pull could not be attempted before early February and might not be completed until some time in the second half of the month.

Among the minor weather hazards in the later fall and early winter was the development of early morning ground fog on the water, due to night condensation from the low temperature. The channels were carefully buoyed to avoid risk of collisions, and red lanterns were hung out in the foggy weather. Safety precautions were so well arranged that only one minor collision occurred during the entire job.

Every weld was X-rayed. There were no field welding failures disclosed on the inspection. Testing was in progress and gas put through the line beyond Kenora before the end of the year.

Vernon Flatte acted as chief inspector for Trans-Canada, which had the contract for supervision and inspection on behalf of the Crown corporation. An unfortunate sequel to the job, and the only fatality in connection with the whole four months' work, was Mr. Flatte's death in a tragic automobile accident when he was returning to his home in Idaho for the Christmas vacation, just after the completion of the north loop of the crossing. ★ ★ ★

Pipe sections made up, ready to be walked into the channel by the big pipelayers seen in the background.

James P. Neill, president of the Pipe Line Contractors Association opens the convention. At his right is Richard A. Gump, executive secretary of the association. To his left are speakers D. A. Golden, president, Northern Ontario Pipe Line Crown Corp., Ottawa, Canada; Curtis M. Smith, president, Southern Gas Association and vice president Tennessee Gas Transmission Co.; and Tom P. Walker, chairman of the board, Transcontinental Gas Pipe Line Corp.

CONTRACTORS PICTORIAL

The meeting was in colorful Boca Raton, Florida

Florida seems to have become a habit with members of the Pipe Line Contractors Association. For the third straight year they gathered for their conclave at the Boca Raton Hotel, and breaking only slightly with custom will meet in 1959 at the new Americana Hotel on the Miami Beach strip. A high all-around standard of excellence was maintained this year. Business sessions were of top caliber, and attendance continued to rise (717 compared with 690 in 1957). Although a serious mien predominated, there was fun too, as some of these informal pictures indicate.

A. S. Rairden, Wickwire Spencer Steel Division, Palmer, Mass.; Paul Gallagher, Colorado Fuel & Iron, Wilmington, Delaware, and Abbott Sparks, The Petroleum Engineer, Dallas, Tex.

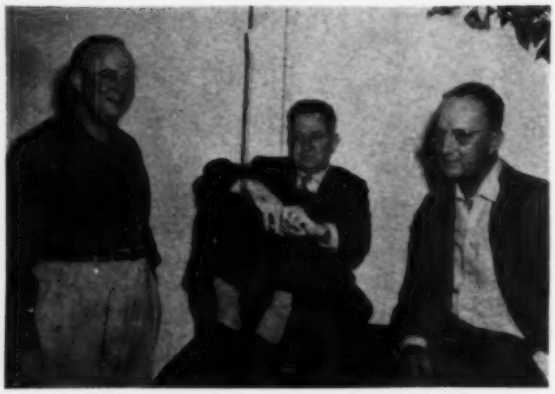
Outgoing Pipe Line Contractors Association President James Neill (R) was presented with a model pipelayer desk set by J. J. Valentine, assistant domestic sales manager, Caterpillar Tractor Co. Five past presidents of the association also were presented with desk sets by Caterpillar.

The Price family: H. C. Price, Sr., Joe, Harold, Jr., Julie, and Harold III, H. C. Price Co., Bartlesville, Oklahoma.

Allan Shivers and E. G. Morrison, Western Pipe Line, Inc., Austin, Tex.

Clyde W. Cook, Grove Valve & Regulator Co., Houston, Tex., and Ben Keller, Tennessee Gas Transmission Co.

A. S. Crutcher, Crutcher-Rolfs-Cummings, with Mr. and Mrs. Paul Ebauch, Cape Construction Co., Cape Girardeau, Mo. Mrs. Ebauch won the sterling silver service given as a door prize at the C-R-C hospitality suite.



Mike Curran, M. J. Crose Mfg., Tulsa, Okla., R. H. Fulton, R. H. Fulton & Co., Lubbock, Tex., and Earl Allen, Associated Pipe Line Contractors, Houston, Tex.

E. J. Mahoney, Jr., Bechtel Corp., San Francisco, and Charley Ice, H. C. Price Co., Bartlesville, Okla.

Howard Margerum, American Bosch, Newark; R. S. Jay, American Bosch, Detroit, Michigan, and F. J. Fetzner, Cleveland Trencher, Cleveland.

← George F. Roberts and W. J. Flaherty, Polyken Division, The Kendall Co., Chicago; Bill Hogan, convention consultant for Pipe Line Contractors Association, and Howard D. Segool, Polyken Division.

Cecil Redding, Gulf States Asphalt Co., Houston; I. W. Dods, Transcontinental Gas Pipe Line Corp., Houston; N. K. McFarland, Lone Star Pipe Line Constructors, Dallas.

Robert Thomas, River Construction Corp., Fort Worth, Tex., and Robert Conyes, Conyes Construction Corp., San Pablo, Calif.

J. P. Neill, Western Construction Co., Dallas; Robert B. Leggett, manager, Boca Raton Hotel; M. E. Fearis, Caterpillar Tractor Co., Peoria, Ill.

Mr. and Mrs. Art Gray, Pittsburgh Coke & Chemical Co., taken on their 19th wedding anniversary.

A. L. Crumback, and Ralph Skinner, Canadian Equipment Sales Co., Edmonton, Alberta, Canada.

Barney Elscott, Cleveland Trencher Co., Cleveland; John L. Root, and Richard C. Graffagna, Barber-Greene Co., Aurora, Ill.

Ed Peters, Huntington, West Virginia; Charley Ice, G. A. Reutzel, and R. E. Burgess, H. C. Price Co., Bartlesville, Okla., and A. T. Chamberlain, Chicago Pneumatic Tool Company, New York.

Eugene Drysdale, H & L Tooth Co., Montebello, Calif.; R. E. Burgess, and R. K. Shivel, H. C. Price Co., Bartlesville, and Richard Launder, H & L Tooth Co.

E. L. Henry, Crutcher-Rolfs-Cummings, Houston, and A. T. Maxwell, Ohio Pipe Line Construction Co., Newark, Ohio.

Don Coonan, Caterpillar Americas Co., Willowdale, Ontario; Roy Price and Bill Cook, Engineers Limited Pipeline Co., San Francisco.

Wayne Fowler, Fowler-Tatom Pipeline Contractors, Inc., Cotton Valley, La.; Milton Williams and Leon Brooks, Williams Pressure Service Co., Shreveport.

Art Gray and J. E. Himmelrich, Pittsburgh Coke & Chemical Co., Pittsburgh.

W. B. "Bill" Haas, Northern Natural Gas Company, Omaha, Nebraska; Felix Johnson, Trojan Construction Co., Oklahoma City, Okla.; A. T. Chamberlain, Chicago Pneumatic Tool Co., New York.

← John Caldwell, Pittsburgh Coke & Chemical Co., Pittsburgh, Pa.; Ned C. Stearns, D. E. Stearns Co., Shreveport, La.; Mrs. S. A. Taylor, Sharman, Allen, Gay & Taylor, Houston; M. W. Belson, D. E. Stearns.

CORROSION FEATURE

Guide to Selection of Coal Tar Coatings for Protection of Metals Underground

PART 1

N. T. Shideler
Pittsburgh Coke & Chemical Company
Pittsburgh, Pennsylvania

PLACING underground of any metal structure, whether it be a pipeline, structural steel, tanks, oilostatic cable piping, or metals for other uses, immediately subjects the structure to a corrosive environment in almost every case. Unless the structure is being placed underground on the basis of a short time life expectancy, and it is not expected to be removed and reused in other type service, the structure should be protected or insulated against corrosion.

Present day mounting cost of materials, labor, and construction demands that every precaution be taken to prevent frequent replacements of metals either above or below ground. Consequently, selection of proper coatings, adequate cleaning, and proper application of the coating, possibly supplemented by cathodic protection, are a necessity in order to avoid expensive replacement cost or expensive cost for additional supplemental application of cathodic protection to protect metal.

Underground Corrosion Problems

It is necessary in designing a new facility to be placed underground or underwater to consider all factors contributing to corrosion that may be encountered under these conditions. Some of these factors are:

1. Density of structures in the area with consequent possibility of stray currents and necessity for good protection of structure. Stray current areas are particularly serious in metropolitan and suburban areas where there are underground cables, surface railroads, power lines, water lines, etc.

2. Good coating protection is essential in metropolitan and urban areas in planning gas transmission and distribution lines, water lines, and oilostatic cable lines because of excessive cost of repairs and danger of breaks or leaks in lines.

3. On pipeline river crossings, the need for adequate coating protection is essential to avoid leaks and costly repairs.

4. Even on structures outside metropolitan and urban areas and away from other underground structures, there is corrosion from soil and stress effects of soils on coatings. A virgin soil may show very low corrosion effects on survey; however, once a soil has been disturbed by the installation of the underground structure, the same known non-corrosive soil may become corrosive simply due to aeration and changes made by opening a trench and backfilling.

5. In many areas where structures are placed underground, soils may have become highly contaminated with acids, alkalies, sewage, mine waters, or even petroleum oils; all of which may cause solution or deterioration of the coating resulting in corrosion on the underground structures. Structures placed either in fresh water or salt water must be protected against the destructive action of barnacles upon the coating, which would result in corrosion.

6. Operating temperature of the underground structure, such as gas pipelines, hot oil lines, steam lines, and oilostatic cable lines must be considered in selecting coating.

It necessarily follows, then, that any metallic structure placed underground where life expectancy is greater than two to five years must be adequately protected. It is true that such structures can be protected against corrosion by application of cathodic protection only; however, in most cases,

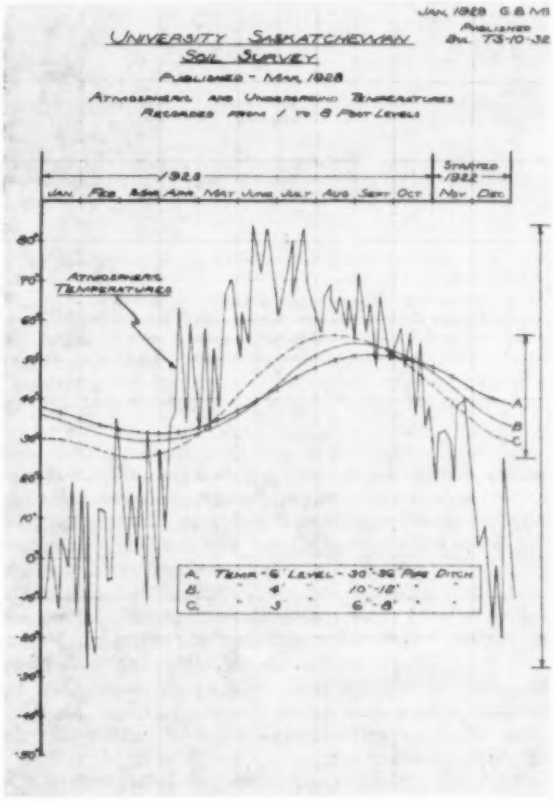

UNIVERSITY SASKATCHEWAN
SOIL SURVEY
PUBLISHED - MAR. 1928
ATMOSPHERIC AND UNDERGROUND TEMPERATURES
RECORDED FROM 1 TO 8 FOOT LEVELS
1928
STARTED 1922
JAN. FEB. MAR. APR. MAY. JUNE. JULY. AUG. SEPT. OCT. NOV. DEC.
ATMOSPHERIC TEMPERATURES
A. TEMP. @ LEVEL - 30"-36" PIPE DITCH
B. " " 9' " 10'-12" " "
C. " " 3' " 6'-8" " "

FIG. 1. Data illustrated here, typical of several studies made at pipeline level, show only slight variation of soil temperatures in relation to atmospheric temperatures, and show why narrow-range enamels perform in service.

What are essential points?

cost of installing of cathodic protection on a bare metallic structure and the current required to protect normally is exorbitant. In almost every case, it is far better for long life expectancy to apply a good coating that can withstand environment and service, and supplement the coating with a small amount of cathodic protection sufficient to maintain the life of the structure. Thus, both coating cost and cathodic protection cost are held to a minimum.

Coal Tar Coatings and Selection

Although the points mentioned above are equally true for use of any coating underground, present consideration is proper use of coal tar coatings. It is not simply the selection of any inexpensive coating to combat what is apparently a mildly corrosive environment, but the selection of a coating that will protect the metal under the most severe conditions, because the corrosive condition quite frequently changes in later years.

Stability, corrosion resistance, and long life of coal tar coatings have been established through more than 40 years of use in the United States alone for the protection of metals underground and underwater. It is quite true that in some cases improper selection, poor metal preparation, and careless application of the coal tar coatings have resulted in

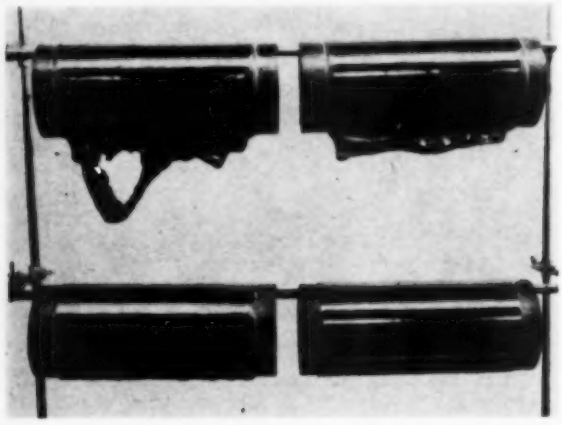


FIG. 2. Laboratory exposure of enamels, without reinforcing or bonded felts on 4-in. pipe.
1. Upper left: Narrow-range enamel, 2 hr at 180 F.
2. Upper right: Moderate-range enamel, 6 hr at 180 F.
3. Lower left: Normal wide-range enamel, 24 hr at 180 F.
4. Lower right: Hot pipeline enamel, 1 week at 180 F.

criticism to the extent that it has been said that coatings have deteriorated.

Actually, the coating in most cases has not deteriorated, but has been moved by outside forces from the surfaces of the structure or from areas of the structure to the extent that bare metal has been exposed, indicating loss of protection. Thus, with knowledge of the performance characteristics of various types of coal tar coatings and underground conditions that may exist, proper selection can be made of the coating to be used, which, together with proper cleaning and application, will insure protection of the metal.

Of the points enumerated, the following are the ones most necessary to consider when selecting the proper coal tar coating:

1. Nature of soils and contaminants in soils around the buried structure.
2. In-service operating temperature of structure.
3. Atmospheric temperature at time of application and during installation.
4. Immersion in fresh water.
5. Salt water immersion.

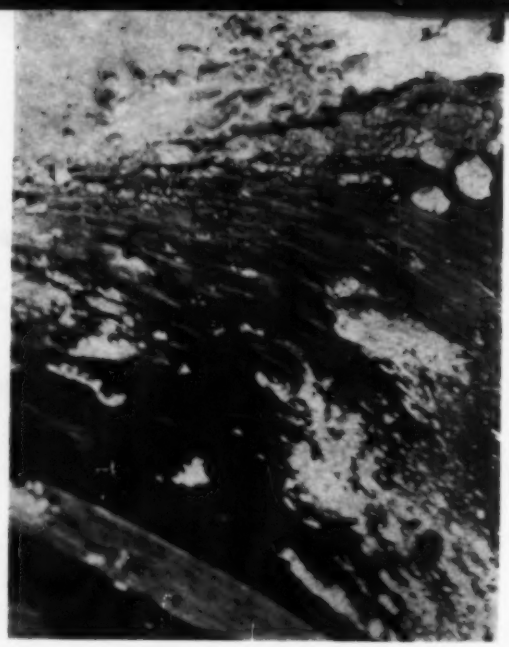


FIG. 3. Narrow-range enamel with glass inner wrap on 26-in. pipe, 6 years in service where gas and pipe temperature was approximately 128-133 F.

Previous publications have shown that there are two types of coal tar coatings: (1) Coal tar enamels that must be heated and applied hot to the metal structure, and (2) cold applied coal tar coatings that can be applied by brush, spray, or roller application without the addition of heat. These two types must be discussed separately.

Hot Applied Coatings

There are many varieties of hot applied coatings, all produced either from straight coal tar pitch and mineral filler or from coal digestion pitches and mineral filler. The latter products have previously been described as consisting essentially of a combination of coal tar pitch, coal tar oil, and bituminous coal processed to a stable pitch of specific softening point and penetration to which is added mineral filler to produce the final hot applied coating.

These hot applied coatings have been divided into three main groups, which have been given the non-commercial names of "narrow-range" "moderate-range" and "wide-range" enamels. Of course, each manufacturer is producing one or more products that fall into each group. For the sake

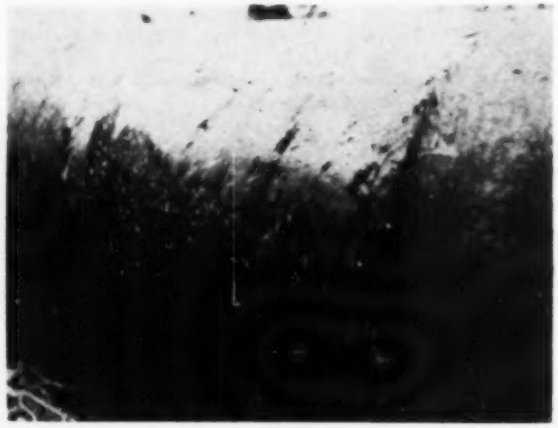


FIG. 4. Narrow-range enamel with glass inner wrap, on 26-in. pipe, 7 years in service, where temperature of gas and pipe was approximately 130 F.

Effect of temperature.

of clarity with regard to specifications and characteristics. Table 1 gives standard specifications for one of the narrow-range, one of the moderate-range, and three of the wide-range enamels. It is of particular importance to note in the specifications the softening points, penetrations, cold test temperatures, and sag test temperatures, for these are the governing factors in making proper selection for use of specific products.

First, consider the temperature range through which these coatings may be used. The "narrow-range" enamel has a softening point usually between 190 and 200 F.

The sag test is at 120 F and cold cracking test temperature is at 30 F (atmospheric temperatures). This means that coating exposed to an atmospheric temperature above 120 F will have a tendency to sag or run from a vertical surface. It will do this slowly because movement characteristic is due to what is termed "cold flow" of the coating. This is best indicated by the fact that although the coal tar pitch used for the production of the coating is a hard, brittle pitch at room temperature, a piece of it left exposed at room temperature over a period of time will flatten out, lose its sharp edges and shape. This is "cold flow."

The same coating applied to metal and exposed to atmospheric temperatures below 30 F is very apt to crack and disbond from the metal. This is largely due to the inflexibility of the coating with rapid changes of temperature and to the fact that the coefficient of expansion and contraction of the coating is approximately 10 times the coefficient of steel. As a consequence, under rapid cooling temperature, which might be referred to as "shock" changes, the coating shrinks so much more than the steel that too much stress is set up in the coating and it cracks and disbonds.

Thus far, in referring to this narrow-range enamel, reference is made only to the actual testing temperature. Minimum atmospheric temperature that coating is exposed to normally is of importance, only while structure is being coated and subsequent to backfilling around the coated structure, as ground temperatures rarely fall below freezing in winter.

There are a few unusual exceptions to this, such as a low-pressure distribution gas line leading off from a high-pressure gas line. It is not uncommon to have the reduction in pressure cause a refrigerating effect on the small line. The high temperature to which the coating is exposed is more critical. The narrow-range enamel, as applied to pipe and tanks where it is reinforced by a wrapper of tar-

FIG. 5 and 6. Narrow-range enamel with tar-saturated felt wrapper, on 30-in. gas line in service 7 years, where gas and pipe temperature was approximately 132 F continuously, on hot side of compressor station.

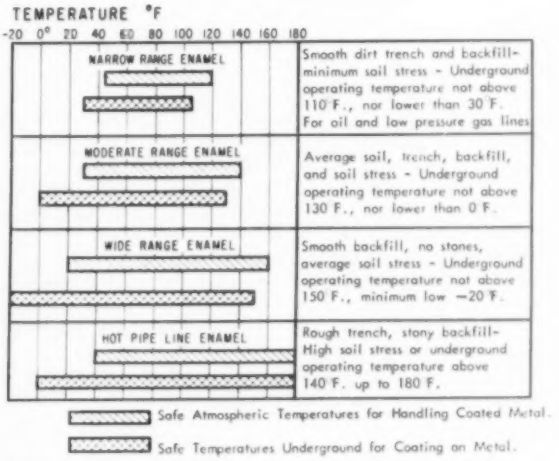

TEMPERATURE °F
-20 0° 20 40 60 80 100 120 140 160 180
NARROW RANGE ENAMEL
Smooth dirt trench and backfill-minimum soil stress - Underground operating temperature not above 110 F., nor lower than 30 F. For oil and low pressure gas lines
MODERATE RANGE ENAMEL
Average soil, trench, backfill, and soil stress - Underground operating temperature not above 130 F., nor lower than 0 F.
WIDE RANGE ENAMEL
Smooth backfill, no stones, average soil stress - Underground operating temperature not above 150 F., minimum low −20 F.
HOT PIPE LINE ENAMEL
Rough trench, stony backfill-High soil stress or underground operating temperature above 140 F. up to 180 F.
Safe Atmospheric Temperatures for Handling Coated Metal.
Safe Temperatures Underground for Coating on Metal.

FIG. 7. Temperature range chart for handling, installation, and underground service of coal tar enamels.

saturated asbestos felt, may be exposed for a few days aboveground to temperatures as high as 140 F, without damage; however, this same coated structure at a constant operating temperature of 120 F or higher may have bare metal exposed after a few months of service due to the slow "cold flow" of the coating. Although the test temperature is 120 F, it has been shown by actual applications that the maximum operating temperature of gas or products lines underground for a narrow-range enamel should not be more than 110 F. Fig. 2, 3, 4, 5, and 6 show the effect of too high an operating temperature.

Explanation of the effects of high and low operating temperatures on the narrow-range enamel can be applied equally well to other hot applied coatings. Thus, Fig. 7 gives a graphic representation of the safe temperature that may be used with each range of enamels. The barred blocks show safe handling temperatures for the atmosphere. Cross-hatched blocks show safe operating temperatures of the coated structure either underground or when exposed to the atmosphere undisturbed by handling or movement. In other words, the moderate-range enamel can be handled safely between atmospheric temperatures of 32 to 140 F. Normal wide-range enamel may be handled safely between 20 and 160 F, whereas the hot pipeline enamel can be handled

Nature of soil important.

safely from approximately 40 to 180 F. In service, operating temperatures that the same coatings can stand are 0 to 130 F on the moderate-range enamel; minus 20 to 150 F on the wide-range enamel, and 0 to 180 F on the hot pipeline enamel.

Specifications given in Table 1 are for five different standard products; ability of the manufacturer to produce coatings from coal-tar pitch having a variety of characteristics with regard to penetration, softening point, and temperature resistance. The coatings are resistant to mineral acids and alkalies of any concentration that would be found in soils, even with spillage of acids and alkalies in the soil. None of these hot applied coal tar coatings is resistant to aromatic solvents and materials of this type. Thus, the coatings on metal underground would be dissolved by a high concentration of such materials spilled into the soil around the coated structure sufficient to remove the coating and permit corrosion.

The narrow-range enamel is quite resistant to crude petroleum and petroleum products; thus, soils contaminated with petroleum products would have no effect on narrow-range enamels. The moderate-range enamels are resistant to light concentrations of petroleum oils in soils but cannot stand heavy concentrations as would occur from a serious overflow of petroleum from a tank. Wide-range enamels are less resistant to petroleum products, with the exception of the hot pipeline enamels, which are similar to the moderate-range enamel in petroleum resistance. Thus, if a very high concentration of petroleum or petroleum products is in the soil, it is well to take this into consideration. If the coating is shielded with tar-saturated asbestos felt, the felt serves to reduce the attack of petroleum oils on both the moderate and wide-range enamels.

Enamels are completely resistant to fresh water or sea water attack as well as mineral salts in water. All coatings exposed in salt water, where barnacles are prevalent, are damaged by the growth of barnacles on the coatings. Thus, if any of the coal tar coatings are used in salt water where barnacles are prevalent, the coating system must be protected in some way, such as with a concrete shield, in order to prevent peeling of the product by barnacle shells.

Nature of the soils in which the buried coated structure is placed has some bearing upon selection of coating. It has been indicated that corrosiveness of soil in all cases except from aromatic product spillage has no effect upon coating. Two conditions of soils do materially affect coatings, however. Certain soils, usually clays of one form or another, in areas where at certain periods of the year the soil dries out and has a tendency to stick tightly to the coating on the coated and wrapped structure, may exert stresses on the coating system and displace them to such an extent that bare metal may be exposed in small areas and the coating drawn into ridges or thick areas, unless proper shielding is used, like gunite or rock shields. This action normally is termed "soil stress" and is the result of adhesion of the clay to the coating and the clay passing through alternate stages of water saturation to complete drying out. Narrow-range enamel has very good resistance to soil stress when the underground operating temperature is below 90 F. The coating is hard, firm, and not easily displaced. Moderate-range enamel and normal wide-range enamels are both able to resist this soil stress at underground temperatures of approximately 110 F and 130 F, respectively. Hot pipeline enamel is quite hard, has practically no cold flow at moderate temperature, and is an excellent coating to use even at temperatures as high as 160 F in high stress soils.

A second soil condition that must be taken into consideration with underground structures is the area where the structure is in rocky soils. In this case, there is always the danger of sharp corners of stone and other hard objects in the soil pressing against the coating, which eventually may cut through the coating to the bare metal. Rocky backfill is not a serious condition, provided proper shielding is given, particularly where supplemental cathodic protection is used. The usual areas of penetration are small, and, as a consequence, require little current to protect exposed areas.

If the underground structure is at ground temperature, danger of penetration of the coating by rocky backfill is not serious, because coatings at normal ground temperature have high resistance to pressure. However, if the structure is constantly at *elevated temperatures* such as are given in Fig. 7 for *maximum* in-service temperature, the coatings are softer and can be penetrated more easily. Use of tar-saturated asbestos felt as an outside wrapper materially helps in protecting the coating both from the standpoint of soil stress and penetration. Hot pipeline enamel, of course, is especially good both for soil stress and poor backfill conditions.

TABLE 1. Typical Specifications, Coal Tar Hot Applied Coatings.

			Wide-range Enamels		
	Narrow-range Enamel	Moderate-range Enamel	Normal Wide-range Enamel	AWWA Enamel C203-4	Hot Pipeline Enamel
Specific gravity 25 C	1.45–1.55	1.40–1.50	1.40–1.50	1.40–1.50	1.40–1.50
Softening point F ASTM D-36	190–200	195–205	220 min.	220 min.	240 min.
Penetration ASTM—D-5					
100 g., 5 sec., 77 F	0–2	2–6	7–11	10–20	1–3
200 g., 5 sec., 77 F					2–6
50 g., 5 sec., 115 F	2–8	8–20	14–28	15–55	5–15
Ash, mineral filler					
Percent by weight	20–25	20–25	20–25	25–35	25–35
Sag test					
7 hours at 120 F	1/16" max.				
7 hours at 140 F		1/16" max.			
24 hours at 160 F			1/16" max.	1/16" max.	
24 hours at 180 F					1/16" max.
Cold cracking test					
5 hours at 30 F	None	—	—	—	—
5 hours at 0 F	—	None	—	—	—
5 hours at –10 F	—	—	—	—	None
5 hours at –20 F	—	—	None	None	—
Spark test					
10,000 V					
Low Amp	None	None	None	None	None

Metal must be primed.

In speaking of hot applied coatings, it has been assumed that everyone is familiar with the application of these coatings. Hot applied coating will not bond to thick metallic surfaces without the use of a primer. Thus, the primer becomes a part of the coating system. Each of the hot applied coatings has its own specific primer made by cutting back with coal tar solvent the same pitch as is used in the enamel, so that the primer can be easily applied by brush, spray, roller, or machine application at normal temperatures.

The primer acts as an insulator on metal surfaces in such a way that when hot coating is applied to the primer, surface of the primer melts and flows into the coating to establish a bond between the metal and the coating.

It is essential that at least a commercially clean metal surface is prepared for application of the primer and subsequent application of enamel. It is also essential that reasonable care be exercised in the application of coating to be sure that it is applied properly, bonded to the metal, and applied in uniform thickness. These are only normal precautions that would be necessary with any type coating system.

Fig. 8 illustrates the function of primers. Enamel applied within the proper temperature ranges, to correctly dried primer, permits the enamel to melt the surface of the primer permitting the two to flow together and thus create a perfect bond. Enamel that is applied *below* the producers'

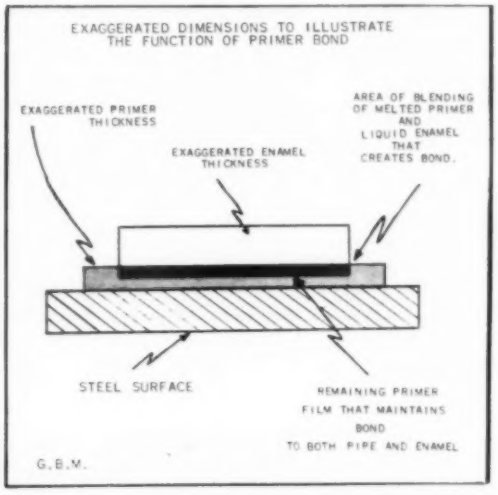

EXAGGERATED DIMENSIONS TO ILLUSTRATE THE FUNCTION OF PRIMER BOND
EXAGGERATED PRIMER THICKNESS
EXAGGERATED ENAMEL THICKNESS
AREA OF BLENDING OF MELTED PRIMER AND LIQUID ENAMEL THAT CREATES BOND.
STEEL SURFACE
REMAINING PRIMER FILM THAT MAINTAINS BOND TO BOTH PIPE AND ENAMEL
G.B.M.

FIG. 8. Illustrating the function of primers.

recommended temperature ranges, or to primed pipe that is too cold, prevents the enamel from melting a sufficient amount of the surface of the primer, and does not provide good bond. Enamel that is applied *too much above* the producers' recommended temperature ranges, results in too thin an enamel application, and would not meet the engineers' requirements.

The first part of this article has dealt with hot applied coatings that have been in use on pipelines, structural steel, tanks, and other structures in this country for a great many years with an enviable record of good performance for a coating material.

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5. W. F. Fair, Jr., "Properties, Specifications, Tests and Recommendations for Coal Tar Coatings," *Corrosion*, November 1956.
6. O. W. Wade, "Economical Design of an External Coating System for a Pipe Line," 4th Annual Corrosion Control Short Course, April 2-4, 1957.

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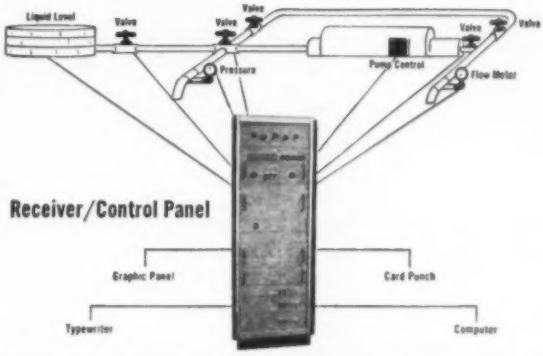

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Pipeline Fundamentals

PREVENTIVE MAINTENANCE

Part 3 - Annual Overhaul Reports

Donald M. Taylor

RECORDS are to gas engine operations, what accounting is to business. They are vital. And they provide the only means of *tight* operation and maintenance.

Ask a business analyst to name the chief cause of business failures, and chances are the first reason he'll cite will be *poor accounting*. He will likely point out that many a businessman has gone broke while thinking he was getting rich. Why? Poor accounting! In contrast, good accounting does more than simply keep track of what comes in and what goes out. It shows accurately **how the business has been doing in the past, how it's doing now, and indicates how it will likely do tomorrow.**

So it is with engine records. They must show how engines have performed in the past — how they are doing today, and project repairs and expenses that should be executed to insure their profitable performance in the future.

To illustrate, let's take an extreme case. Suppose a crankshaft breaks, greatly damaging a particular engine. Obviously, there's little that can be done for this particular engine except to make repairs or possibly replace it.

But what of similar engines on the system? From records of the engine that failed (and from examination of the breakage), the cause of its failure can be determined. By checking the records of similar engines against the records of this particular engine, additional failures possibly can be prevented.

Moreover, these same records cannot only help spot trends in engine failures, they can serve as a yardstick for efficiency of engine operation and maintenance. To perform these functions, the information contained in the records all should be *useful*.

What are useful records? They are records that will be *used*. Records kept for records sake not only are useless —they mask or cover up information that is necessary for accurate maintenance appraisal.

Examples of useful records. Transcontinental Gas Pipe Line Corporation has an enviable record in maintenance and operation of gas engines. The company's availability factor is one of the highest in the industry, and there is little doubt that the company has sidestepped more engine trouble than it allowed to materialize. For this reason, *The Pipeline Engineer* requested permission to reprint most of the overhaul record forms used by Transco's compressor department.

It should be pointed out that these forms are the product of no one man. Nearly every superintendent on the system has made suggestions that have been incorporated in the final results.

FIG. 1. Recap of major materials used by Transcontinental Gas in its 1957 annual overhaul—excluding steam stations.

Station No.	Power cylinders	Power pistons	Power piston heads	Power cylinder heads	Compressor piston rings	Power piston rings		Percent replacement	Wear rings	Main bearing halves	Rod bearing halves	Blower rotor	Scavenging crosshead
						Compression	Oil						
2	—	—	—	—	—	17	3	7	—	1	—	—	—
3	—	8	—	1	—	91	60	43	2	—	—	—	—
4	1	17	—	—	10	58	93	36	11	—	—	—	—
6	11	8	—	—	—	81	34	24	—	—	—	—	—
8	2	18	—	—	—	90	80	35	—	—	—	—	—
9	—	6	—	—	36	56	199	53	—	—	—	—	—
11	3	6	—	—	6	114	39	32	—	—	—	—	—
12	4	1	—	3	24	52	17	14	—	—	—	1	—
13	—	—	—	—	—	20	—	4	—	—	4	—	—
14	5	3	—	—	3	51	13	15	—	—	—	—	—
15	3	—	15	—	—	45	14	13	14	—	19	—	1
16	—	—	18	—	—	78	18	23	—	2	12	—	—
17	1	1	—	1	—	9	3	3	—	—	—	—	—
18	—	—	10	—	8	39	—	10	—	—	7	—	—
19	—	—	2	—	—	31	1	8	—	4	—	—	—
20	—	—	2	—	—	22	—	6	—	5	2	—	—
Totals	30	68	47	5	87	854	574	21%	27	12	44	1	1

PRACTICES FOR GAS ENGINES

And, even though the record forms are splendid maintenance tools today, they will likely be revised and improved again and again in the years to come.

But before we discuss the individual forms, let's clarify one point. These particular forms may be meaningless in themselves. To be useful, they must be combined with summaries of daily and monthly operating logs, etc., that are necessary to round out the picture.

Shown in Fig. 1 is a recap of major materials used in Transco's annual 1957 overhaul. Its primary purpose is to provide an appraisal of maintenance and operation and to raise questions and point out problems that should be looked into.

RECORD FORMS

A form for summarizing labor costs and major material items used at each particular station is shown in Fig. 3.

Ring groove wear. Fig. 2 shows a

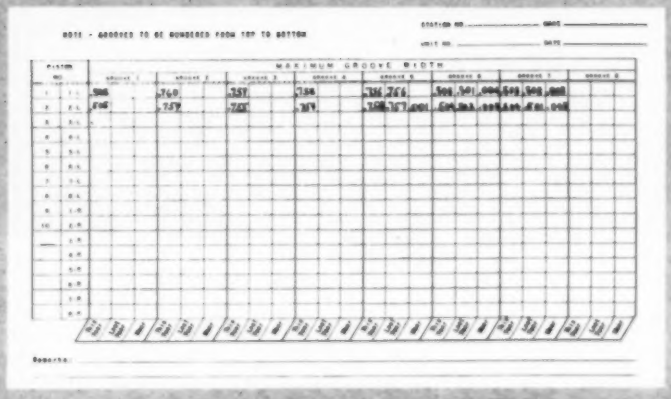

FIG. 2. Annual overhaul report on power piston ring grooves, micrometer readings.

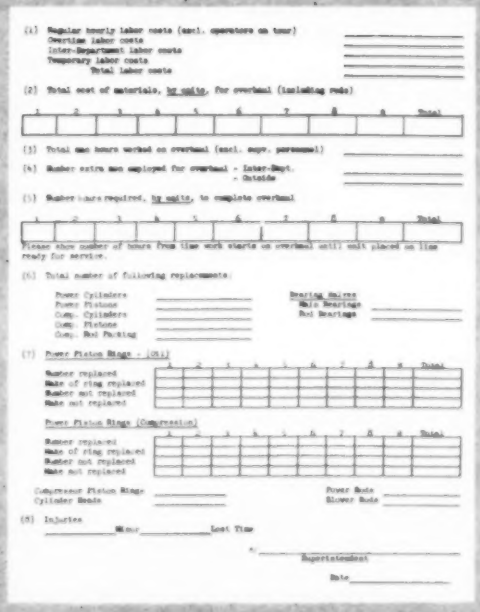

FIG. 3. Transco's annual overhaul summary shows labor and materials broken down into cost figures.

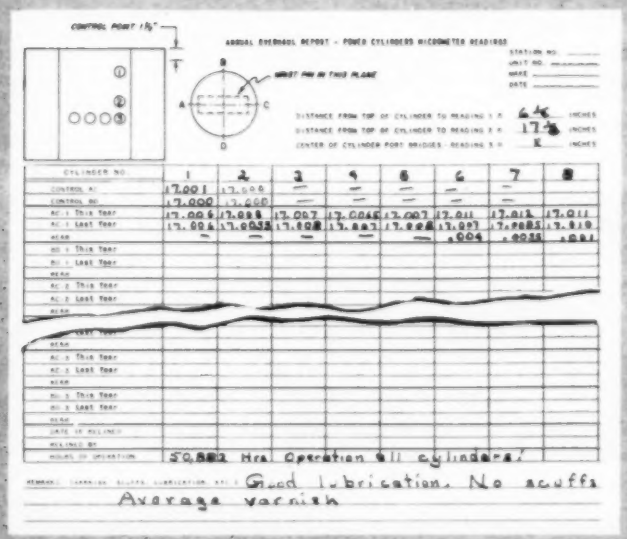
ANNUAL OVERHAUL REPORT - POWER CYLINDERS MICROMETER READINGS
CYLINDER NO.
50,883 Hrs. Operation all cylinders
Good lubrication. No scuffs
Average varnish

FIG. 4. Note that readings are taken at points above cylinder wear. These control readings can make errors obvious.

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The group of anodes produced an average of 33 amps at 36 volts with no tendency to gas block. Actually, the bed resistance has decreased since the original installation. There was considerable cost-saving in the elimination of carbonaceous backfill.

- Duriron anodes, bare or with backfill, resist all current densities common to ground bed applications.
- Duriron resists all soils. Care required only when operating at high current densities in high chloride areas.
- Duriron has dense structure. Will not absorb moisture or gases causing breakdown. High weight factor gives longer life per anode size.
- Duriron has good electrical conductivity. Minimizes heavy current discharge near connection for uniform consumption.
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portion of the form used for recording ring groove wear. Note that spaces are provided for recording the previous year's readings, thus making it easy to calculate the wear experienced in a year's operation.

Power cylinder micrometer readings. Fig. 4 shows readings that are duplicated as nearly as possible from year to year. The first and most important reading taken in each instance is that of the control point, which is in the upper portion of the cylinder where no wear will occur. Purpose of this measurement is to take care of differences in temperature and individual measuring practices, which will vary from person to person. You will note that some of the cylinders show from one to half a thousandth decrease in diameter. This is an error that possibly came from temperature differences.

To aid repairmen in duplicating measurements, Transco uses a version of a metal tee-square shown in Fig. 11.

Piston rings. The decision as to when to replace a piston ring is hard to pin down. Because of the differences in shapes of cylinder liners, an old ring that has had a year or so of service may be far better than a new ring.

Perhaps the best indication that a ring is not doing its job is evidence of blow-by or cylinder wall scuffing. Blow-by usually is easy to detect. An experienced operator can listen to the engine through a stethescope and pretty well pick out cylinders where blow-by is occurring. Moreover, the varnish on the cylinder wall also will give a good indication.

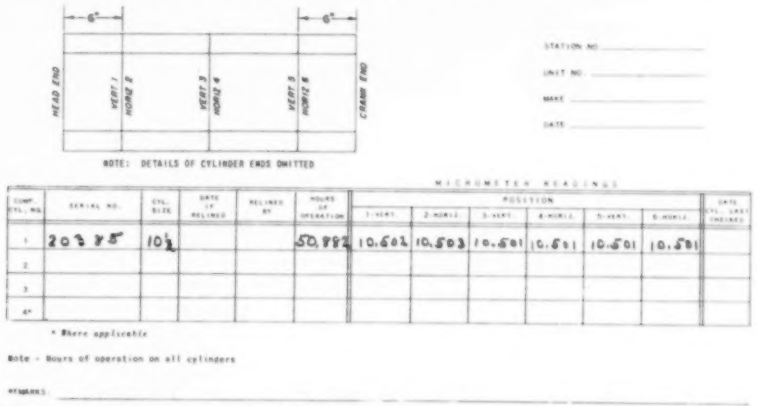
Fig. 5 shows a record form for power piston rings. Note that the number of operating hours is shown for each individual ring.

Compressor cylinder inspection during overhaul should be simply a spot check in most instances because most gas transmission systems handle clean gas. As a general rule, certain cylinders will undergo most wear, depending on the shape and size of the suction bottle. Transcontinental Gas usually inspects compressors on a single engine during each annual overhaul. Should wear prove excessive, other cylinders will be inspected and remedial action taken.

Fig. 6 and 7 show the forms Transco uses to record this information.

PISTON NO.		1	2	3	4	5	6	7	8
1	Make	—							
	Model Number	101-5LA							
	Date Installed	6-13-57							
	Engine Hours	0							
2	Make	—							
	Model Number	101-8							
	Date Installed	5-13-57							
	Engine Hours	0							
3	Make	—							
	Model Number	101-8							
	Date Installed	5-13-57							
	Engine Hours	—							
4	Make	—							
	Model Number	101-8							
	Date Installed	6-13-57							
	Engine Hours	0							
5	Make	—							
	Model Number	101-8							
	Date Installed	2-16-51							
	Engine Hours	50,882							
6	Make	—							
	Model Number	303-DLK							
	Date Installed	5-13-57							

FIG. 5. Annual overhaul report on power piston rings. Ring replacement is more or less left up to the good judgment of repair crews.



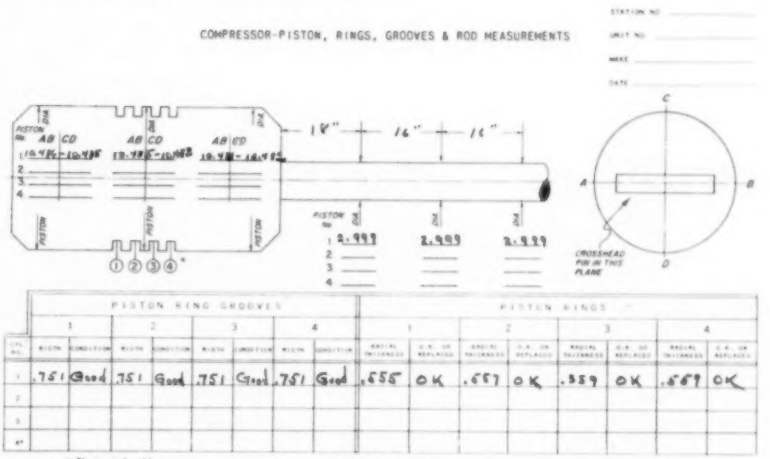
COMP. CYL. NO.	SERIAL NO.	CYL. SIZE	DATE LAST RELINED	RELINED BY	HOURS OF OPERATION	POSITION 1-VERT.	POSITION 2-HORIZ.	POSITION 3-VERT.	POSITION 4-HORIZ.	POSITION 5-VERT.	POSITION 6-HORIZ.	DATE CYL. LAST INSPECTED
1	20285	10½			50,882	10.502	10.503	10.501	10.501	10.501	10.501	
2												
3												
4*												

* Where applicable

Note - Hours of operation on all cylinders

REMARKS: _____

FIG. 6. Compressor cylinder micrometer measurements. This is a yearly spot check — not all cylinders are measured.



COMPRESSOR-PISTON, RINGS, GROOVES & ROD MEASUREMENTS

PISTON NO.	PISTON RING GROOVES 1	2	3	4	PISTON RINGS 1	2	3	4
1	.751 Good	.751 Good	.751 Good	.751 Good	.655 OK	.657 OK	.659 OK	.669 OK
2								
3								
4*								

* Where applicable

REMARKS: _____

FIG. 7. This spot check of compressor pistons is sufficient — No. 2 cylinder usually shows most wear.

NOTES ON TAKING MEASUREMENTS DURING OVERHAUL

Here are some of the methods that can be used in taking measurements of engines as they are disassembled, repaired, and placed back on the line. The crossheads and similar measurements are made with feeler gages — other parts are simply inspected visually. But the particular methods shown below may point the way to a shortcut or two—even for experienced operators.

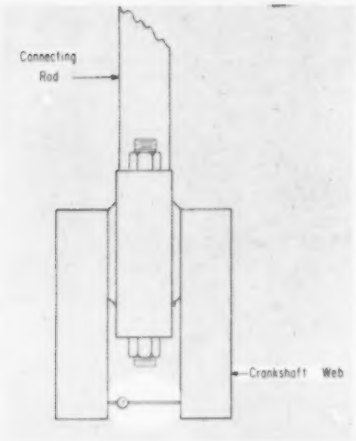


Fig. 8. **How to measure crankshaft deflection.** This is a relative measurement aimed at showing whether the crankshaft is bent or not supported by its bearings properly. To make the measurement, center punch the webs so the micrometer can be suspended between them as shown. Whirl the dial before starting the measurements to be sure the extension points are seated properly. Then rotate the engine, taking measurements at bottom dead center horizontal position and as near as possible to top dead center. Although these measurements cannot be taken as having absolute accuracy (no great effort is made to centerpunch the webs with great accuracy to begin with) any variation in excess of 0.003-in. will denote trouble.

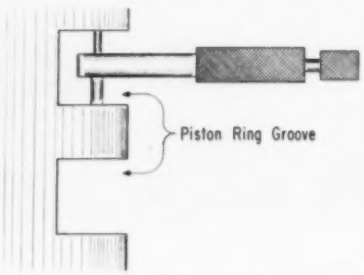


Fig. 9. **How to measure piston ring groove wear.** After cleaning the grooves, slide a telescoping gage around the groove seeking the widest clearance. There are other ways of doing this — one is to use a machined piece of piston ring in combination with feeler gages — but this inexpensive telescoping gage that can be locked by the knurled knob on the end is the fastest.

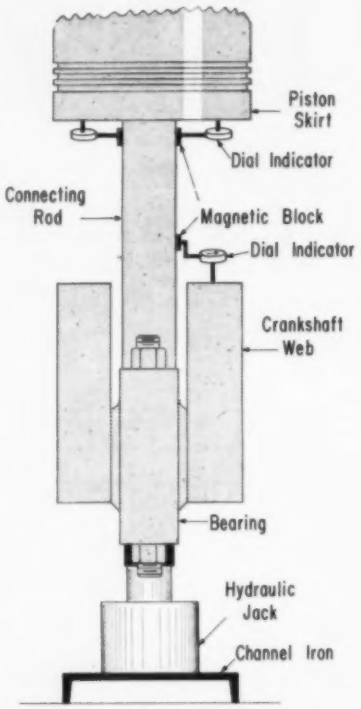
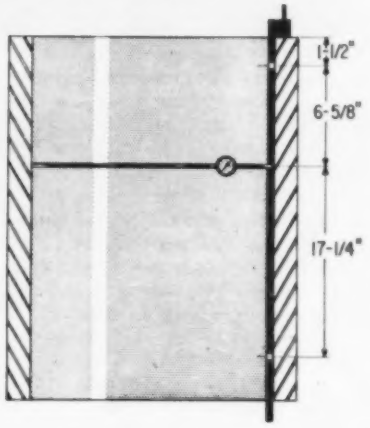


Fig. 10. **How to measure power bearing and wrist pin clearances simultaneously.** Mount two magnetic base dial indicators on the piston rod against the piston skirt, as shown, and another dial indicator between the rod and a machined part on the crankshaft, with the piston at bottom dead center. Mount a hydraulic jack on a piece of 8-in. channel iron that spans the crankcase. As the jack goes up, the lower dial will read bearing clearance. Subtract the latter reading from the average of the two upper dials to determine wrist pin clearance.

Fig. 11. **How to measure cylinder wear.** Make a tee-square out of steel strap and bore holes at the intervals desired for taking measurements. The upper hole should be above the cylinder wear so that each reading will have a control measurement. Place the tee-square in the cylinder liner at right angles to the crankshaft and take readings through each of the holes — then turn the square at right angles (with the upper part parallel to the crankshaft) and repeat the readings. This will give readings that will correlate with one another from year to year.



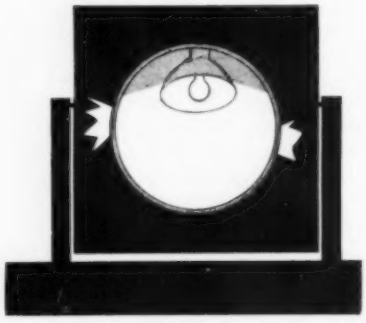


Fig. 12. **A light gage will help you judge rings.** There is no true method of judging the piston rings except perhaps in a brand new cylinder. A ring with a flat surface that has been in use for several years may actually be the truest because it may fit a flat portion of the cylinder. However, rings *do* wear beyond usefulness and they *must* be replaced from time to time. The best gage of all is an experienced eye and a light gage. The gage is carefully machined to the exact shape of a cylinder and when a ring is placed in it and illuminated from the rear imperfections will show clearly.

Conclusion. There are many tricks in taking measurements. No two operating men will take all of them in exactly the same manner. But the important thing is to develop methods that will produce accurate and speedy readings that are so necessary to successful engine operation. ★ ★ ★

CANADIAN NEWS NOTES

Gas Supply for Export is Assured

Contracts for more than the initial requirements of its proposed natural gas pipeline from Alberta to northern California have been signed by Alberta and Southern Gas Company, Ltd., with producers in the principal fields of the Rocky Mountain, foothills, and western plains regions of Alberta. Initial volume planned is 450 MMcf per day, but the company recently contracted for or optioned another 175 MMcf per day from a group of fields in which Texaco Exploration has a large share, including the new Castle River field in the southwestern corner of the province.

Alberta and Southern has an application pending before the Alberta Conservation Board for permission to export the gas, but if it does obtain an Alberta permit it will still face an indefinite delay in going before the Dominion Board of Transport Commissioners and the dominion cabinet. Federal policy at present is to delay all export applications until the Borden Royal Commission on energy resources has reported. This will not be before next fall, according to its schedule of sittings, which only began on February 3 in Calgary.

Interprovincial Carried More Oil in 1957

Interprovincial Pipe Line Company carried 99,900,000 bbl of oil in 1957, compared to 96,700,000 bbl in 1956, according to the preliminary annual report. Barrel mileage was not stated, but was reported moderately lower than in 1956 because of the much larger volume of intermediate traffic out of southeastern Saskatchewan. This short-distance throughput increased from 16 to 35 percent of all that was carried by the line.

Westspur Pipe Line Has Rising Throughput

Westspur Pipe Line Company, serving the southeastern Saskatchewan oil fields, is continuing to enjoy steadily rising throughput. December figures, released in January, revealed a 30 percent increase over November to a new record high of 2,365,270 bbl delivered, or 75,000 bbl per day. This is double the volume carried in January 1957.

The northern states export market took greatly increased quantities in December, and smaller increases were made across the board by the Winnipeg, Sarnia, and Toronto area refineries.

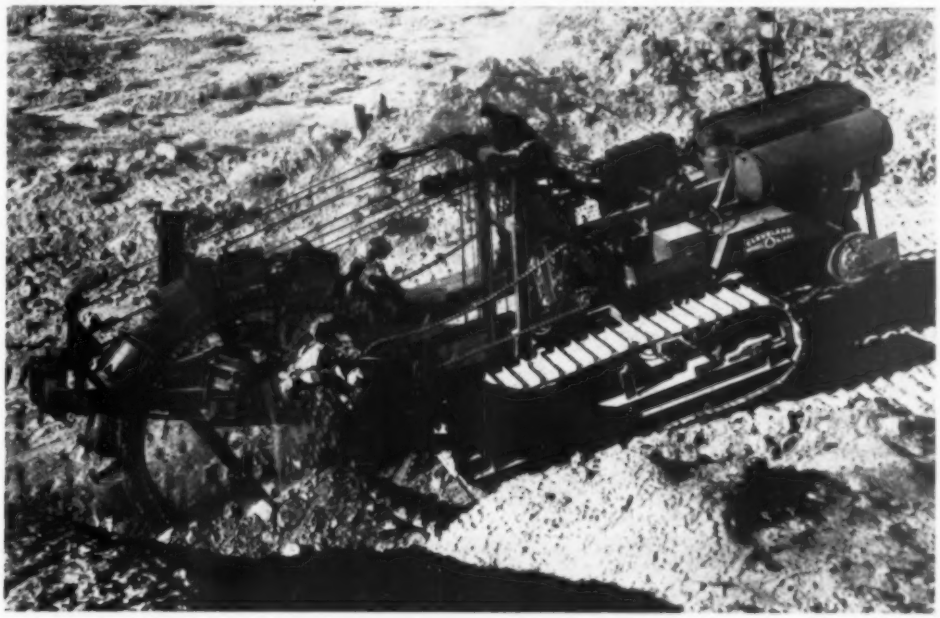
Northwestern Utilities Plans Large Expansion

A large capital expansion program is being undertaken this year by Northwestern Utilities Ltd., the northern Alberta natural gas distribution utility with head office in Edmonton. Major part is a main line and gathering system to carry gas from the Pembina field to Edmonton, where it will be used in the city distribution system. The gas is to be supplied from a conservation plant, which will extract it from current oil production.

Northwestern will lay 49 miles of gathering lines from 16 in. down to 4½-in. diam, and will install two buried river crossings, of the Pembina River (8⅝ in. OD) and the North Saskatchewan River (16 in.).

Main transmission lines will be 71 miles of 16-in. pipe, but the company will lay only 45 miles as new construction. The remaining 26 miles will consist of a loop, which was laid by Pembina Pipe Line, Ltd., last spring for its main crude oil line, but which is now surplus because of greatly reduced throughput.

Between 70 and 80 miles of other lines will be laid for extensions to the main system, to take in towns and cities not now on the line.



THE REDWASH OIL BASIN doesn't give a trencher much to dig in except hard rock, but this Cleveland 240 is making money for its owner as it grinds out trench for a flow line in rugged terrain 30 miles east of Vernal, Utah.

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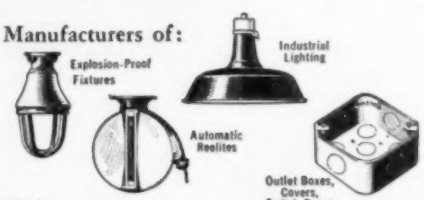

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CORROSION FEATURE

Part 3

George B. McComb
Consultant
St. Louis, Missouri

ELECTRICAL INSULATION OF UNDERGROUND PIPELINES

IN REQUESTING information from a large number of correspondents, and searching the literature, it was surprising to find how much interest there is within the pipeline industry on the effect of soil moisture, soil chemicals, and bacteria on different types of coating systems. (How all this is related to electrical insulation values of coating after 10 to 15 years. What effect this has on the eventual cost of cathodic protection, and why costs on well protected lines have not increased materially, whereas on unprotected lines they have become a substantial part of annual maintenance expense.)

When these high maintenance and operating costs, the result of corrosion or poorly selected protective coating systems, together with the loss of gas, crude oil, and products, are considered, then some of the forecasts of annual cost of corrosion may conceivably be too low, ". . . because in 1957 it is estimated there are almost one million miles of gas, water, oil and/or products pipelines in the USA. . . ."

Much information is available on soil moisture content at different depths, through federal agencies like the Forest Service, Soil Conservation Services, Geological Surveys, Bureau of Reclamation, U. S. Army Engineers, and also the engineering and experimental stations of the different state colleges and universities, and state highway departments.

How To Make Moisture Tests

Many methods are used to make these determinations, in addition to taking the original weight of a soil sample, drying in an oven, and finding the moisture loss after the final weighing.

Some have used the glass fiber soil moisture unit developed by the California Forest and Ranger Experimental Station, which measures both soil moisture and temperature at different levels, as illustrated in Fig. 1.[1]

Considerable progress has been made in developing nuclear soil measurement meters, which give a measurement of soil moisture by the neutron-scattering technique.

These portable instruments were developed for rapid determination of soil moisture content. Measurements are obtained with a moisture probe, which can measure a spherical volume of soil from 14 to 30 in. in diam, and within these volumetric limits at depths up to 60 ft. Originally developed to speed soil moisture and density studies prior to construction of airfield runways, these nuclear measuring techniques have proved readily applicable within a saving in time and labor on other types of industrial construction.[2] Possibly they will be used some time in the future on pipeline construction and corrosion tests or investigations.

Fig. 2 illustrates the dual purpose probe, which contains a radioactive source and detector system. The large cylinder around the probe is a safety carrying shield. The scaler counts impulses received from the probe, after the probe has been lowered to the desired depth. The cable is marked at intervals to determine the probe's depth.[2]

The Soil and Water Conservation Research Branch of the U. S. Department of Agriculture at Tuscon reports: ". . . we have made many soil moisture determinations in upland desert areas, both in the vicinity of pipelines and away. It has been our observation that whenever native vegetation has been removed, as it is along pipelines by clearing right-of-way, moisture levels in the soil build up to field capacity, and if plants are not allowed to grow the moistures remain at high levels. In the vicinity of pipelines where heat is conducted away so readily, you find mass migration of moisture with resultant condensation at ditch bottom. Even in dry soil areas it is a common observation that during portions of the year these levels build up to such an extent that free water is present. It was found that it was not necessary that the pipe be cooled below dew-point for moisture to concentrate . . ."[3]

In previous parts of this series we reported the result of both consumer and producer testing for water absorption of different pipe coatings. One series of tests that started about

FIG. 1

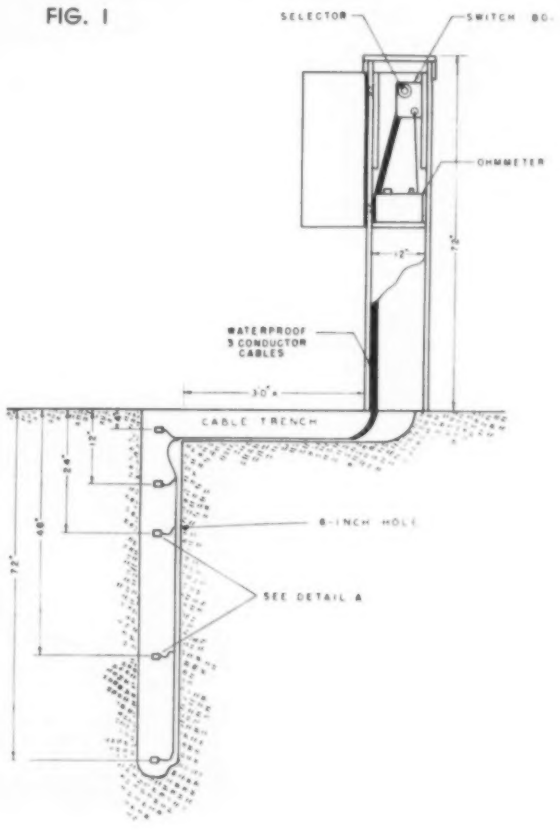

FIG. 2

1952, and is being continued to date, makes use of the Dean Stark apparatus, in accordance with ASTM Method D 95-46. This method determines the moisture content of the coating by actual distillation of the moisture from the coating into a calibrated trap, which measures the actual moisture content. (See Fig. 3).

The procedure in this test follows: Specimens of the coating to be tested by immersion in water are prepared by pouring the melted material into a mould to give a slab of approximately the following dimensions: 5½ in. by 3 in. by ¼ in.

These specimens will weigh approximately 100 grams, and for ease of calibration the ends of the strips of coating are trimmed with a hot knife to make each specimen weigh 100 ± 0.5 grams, and as many as 30 specimens are prepared for *each* of the different materials to be tested.

After preparation of the samples, they are suspended in suitable "battery jars," and tap water sufficient to cover the specimens is poured in, then the top of the jar sealed.

Periodically a specimen is taken out, wiped free of surface moisture, broken into very small pieces, and placed in a 500 ml round bottom flask. Each time a specimen is removed, water in these "battery jars" is changed.

One hundred millileters of pure water-free xylene is added to the flask and the trap and condenser assembled. Heat is applied and the water and xylene distilled. The amount of water is measured directly from the graduated trap.

Water absorption is recorded in percent by weight, and also by grams per square foot of exposed surface. Areas of both sides and edges exposed to the water are taken into account in calculating the area of the specimens. Fig. 4 gives a graphic representation of the water absorption of the three present day top quality asphalt enamels, along with a currently produced moderate range coal-tar enamel.

Data collected by this method, because the specimens are reduced to small particles, actually measures the moisture content of the film, and disproves the theory of surface absorption, and also verifies the typical results of many tests as shown in Fig. 5.

Data shown in Fig. 5 and obtained from coated plates immersed in water and weighed periodically, are representative of many consumer and producer tests. These show that coal-tar enamels early reach a stable position with little

change after approximately three to five years, while the currently available asphalt enamels produced from either air blown straight bases, catalytically blown bases, or vacuum distilled bases, and/or fortified with waxes or resins, progressively show an increase in moisture absorption and reduction in electrical resistance.

Corrosion Basically Electrochemical

In the beginning, in an attempt to control underground pipeline corrosion, numerous systems were devised, i.e., combinations of materials, wrappings, reinforcements, and shielding, to isolate soil moisture from the pipe.

In one period of the development of the art of underground pipe protection, only so-called hot spots were protected. Following this, because corrosion was concentrated at or near the points where the coating had been discontinued at the hot spot, industry began to recognize that, in addition to the soil chemicals which were until then supposed to determine corrosive areas, there are long line currents or those that originate from man made sources. From these two evolved the currently accepted theory that corrosion basically is electrochemical. Then about 1930, the practice of continuous coating and wrapping became accepted procedure.

After many field tests were conducted by many companies, and from the API and AGA investigations, it developed that the coating systems giving adequate "electrical insulation" over a long period of years included the use of low cost cathodic protection.

At this stage of development, it was emphasized that the performance of coal-tar enamels, which because of low or negligible moisture penetration, by the same token had the greatest electrical resistivities. This focused attention on their electrical insulation values.

It is unusual for a product to hold its position over such a long period of time; however, it is not surprising when it is realized that the water absorption, or moisture permeability of coal-tar enamels is extremely low, as has been pointed out by the tests described in Parts 1 and 2 of this series.

The water works industry helps to demonstrate the permeability and resistance to water absorption of coal-tar enamels due to their constant contact with water:

"In 1914 a water line 8000 ft, 42 in. diam was laid in Brooklyn, New York. As a test of protective coatings, a section of approximately 2000 ft was coated and lined with coal-tar enamel by hand daubing. An adjacent 2000 ft was coated and lined with asphalt enamel. The last inspection of this line, which is still in service, was made in 1945 (31 years after installation) and revealed the coal-tar enamel looked exactly as it did the day it was applied, even the brush marks were still visible on the lining, no penetration of the enamel lining. The asphalt enamel on the other section had long since disappeared, only minor traces were evident in 1945. Four other types of coatings were used on the remaining 4000 ft, and also there were only traces of them at the time of inspection.

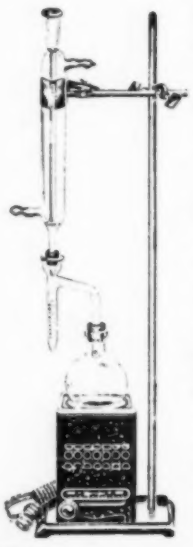

FIG. 3

"In 1932 the Panther Valley Water Company of Landsford, Pennsylvania, installed 10 miles of 30-in. steel pipeline, which was coated and lined centrifugally, with a 3/32-in. thickness of coal-tar enamel. The Average "C" as determined by the

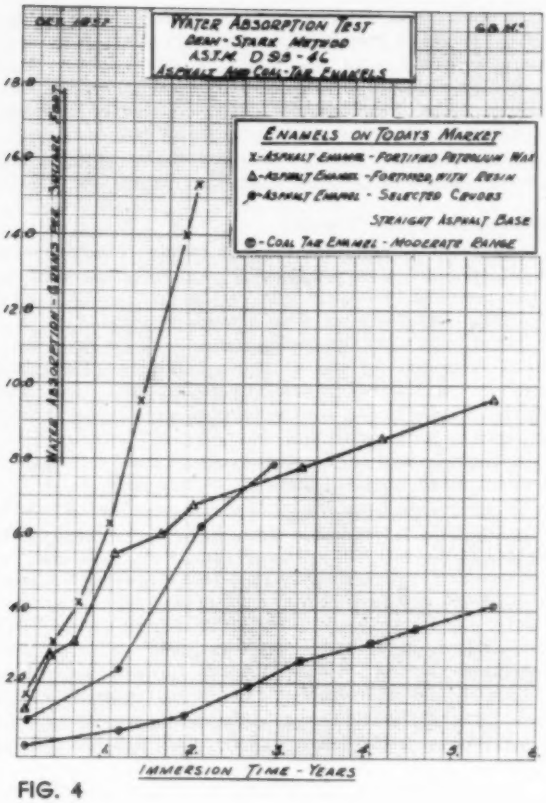
WATER ABSORPTION TEST
DEW-STARK METHOD
A.S.T.M. D 95-46
ASPHALT AND COAL-TAR ENAMELS
ENAMELS ON TODAYS MARKET
X-ASPHALT ENAMEL - FORTIFIED PETROLEUM WAX
Δ-ASPHALT ENAMEL - FORTIFIED WITH RESIN
β-ASPHALT ENAMEL - SELECTED CRUDES
STRAIGHT ASPHALT BASE
●-COAL TAR ENAMEL - MODERATE RANGE
WATER ABSORPTION - GRAMS PER SQUARE FOOT
IMMERSION TIME - YEARS

FIG. 4

flow tests in 1933 and in 1940 was about 145, indicating that it was the same as when installed, with no damage to the coal-tar enamel linings . . . 25 years later, the exterior coating has not been damaged, even with the pipe buried in a very corrosive soil, lots of coal-spoil banks, etc., along the right-of-way."

Coal-tar coatings removed from pipe taken out of service after 20 or 30 years underground, where soil moisture contents range from 20 to 40 percent, show no corrosion whatever underneath the coatings unless the coating had been damaged in the original construction and no repairs made, or the coatings had been displaced by rocks, rough ditch bottoms, soil stress, the result of none or inadequate shielding, etc. Even under these circumstances no disbonding of the enamel has been found, and corrosion is localized in the damaged areas. This is another reason why cathodic protection can be applied at a minimum cost per mile per year. It has been demonstrated many times over the years in the reclamation of thousands of miles of obsolete gas and oil lines.

Fig. 6 illustrates the bond of coal-tar coating, which was so perfect it had to be hammered off. Original mill marks still show after 16 years' service. The line was relaid in a new location, with coal-tar enamel and asbestos felt wrapper applied, and now 15 years later minimum current is applied for low cost cathodic protection, another example of how pipe can be reclaimed, of importance when new steel prices are advancing.

Fig. 7 illustrates the type of anaerobic bacteria corrosion found under an asphalt enamel and asbestos felt coating system, after 10 years' service in an arid area where moisture was present in substantial quantity between the coating and pipe.

Fig. 8 illustrates the results of a combination of disbonding and moisture penetration, under normal soil moisture conditions (20 to 25 percent), which permitted both pitting and soil alkali attack under an asphalt enamel, double-wrap system, after 12 years' service.

High electrical resistivity due to low moisture penetration, and the stability of coal-tar pitches from which coal-tar enamels are made, gives them outstanding electrical insulation values, which permit hundreds of case histories to illustrate the economical use of cathodic protection.

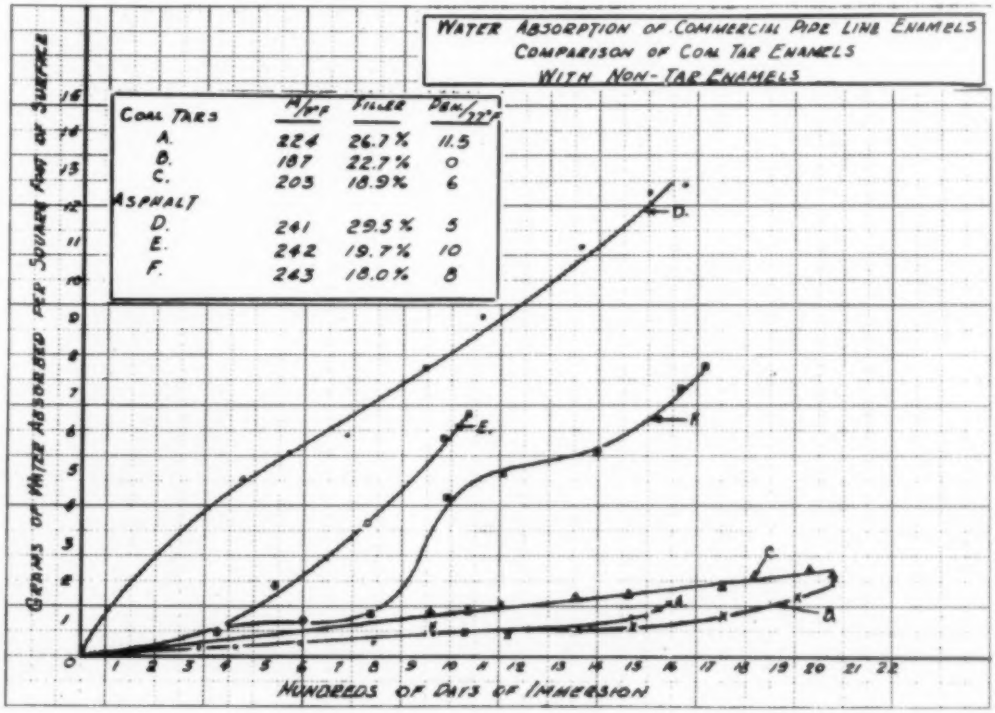
WATER ABSORPTION OF COMMERCIAL PIPE LINE ENAMELS
COMPARISON OF COAL TAR ENAMELS
WITH NON-TAR ENAMELS
COAL TARS
A. 224 26.7% 11.5
B. 187 22.7% 0
C. 203 18.9% 6
ASPHALT
D. 241 29.5% 5
E. 242 19.7% 10
F. 243 18.0% 8
GRAMS OF WATER ABSORBED PER SQUARE FOOT OF SURFACE
HUNDREDS OF DAYS OF IMMERSION

FIG. 5

FIG. 6

Median Power Costs

A survey of 28 pipeline companies, representing approximately 63,000 miles of lines laid from 1930 to 1955, indicated that the median power costs per mile per year, for cathodic protection of coated lines was $4.85, and that the median power cost for bare pipe was $53.90 per mile per year. Indications are that one-half the reporting companies have more than 90 percent of their facilities under cathodic protection.[4]

One large gas utility spent $1,793,107 to install cathodic protection equipment on 5194 miles of 3-in. equivalent pipe, either bare or poorly coated, at an average cost to install per mile of $345.22. The 1955 operating and maintenance cost was $133,018, or an annual operating and maintenance cost, per mile of 3 in. equivalent, per year of $25.61.[5]

In comparison, on 23,646 miles of 3-in. equivalent well-coated pipe (better than four times the mileage of the above) the cost to install cathodic protection equipment amounted to $400,104, or an average cost of $16.92 per mile. The 1955 operating and maintenance costs were $36,-586, or an operation and maintenance cost, per mile of 3-in. equivalent per year, of $1.55.[5]

The picture used in Part 2 of this series (Fig. 2) shows visually the difference in absorption of water by asphalt enamels compared to coal-tar enamel.

Specimen "A" (Asphalt Enamel) absorbed an average of 0.210 grams per year, and in 8 years this amounted to 1.68 grams, which was 8.8 times more than Specimen "B."

Specimen "B" (coal-tar enamel) absorbed an average of 0.024 grams per year, and in 8 years this amounted to 0.19 grams.

Fig. 8 used in Part 1 of this series, illustrates data on water absorption collected that can be used, based on the weight of samples tested, to project the performance over an extended period of years, and its relation to changes in electrical resistance.

For example, to illustrate how this can be approached: Five specimen of each enamel tested were selected, approximately in the middle of this performance data, neither the best, nor the worst, but, representative of the enamels available on today's market, and have been projected in Fig. 9.

What the Tests Showed

An examination of the coatings in tests conducted by consumers laboratories repeatedly show there has been no chemical change or oxidation of the coal-tar pitch type enamels, after many years' service underground.

Fig. 10 illustrates the findings on a 26-in. gas main, protected with coal-tar enamel and asbestos felt. Examined after 10 years' service it showed perfect bond, as indicated by the circular marks, the results of hammering to remove the coating for examination.

It might be well at this point to clarify some information that frequently occurs in literature, technical papers, etc.

Frequent references are made to the asphalt-mastic coatings, and their performance in the API and AGA tests conducted in the early 30's. The specimens were prepared by the use of: (1) A cold applied cut-back primer; (2) a flood coat of hot applied air blown asphalt ⅛ in. thick (without filler), (3) immediately followed by the extrusion of the mastic. The mastic in these tests was composed of 85 percent aggregate and 15 percent asphalt, and was applied to a thickness of ½ in. or more. It should be remembered that the commercially applied mastics since then have eliminated the "bonding agent" (the hot applied unfilled asphalt ⅛ in. thick).

". . . These mastic coatings usually require more current for effective cathodic protection than coal-tar enamel systems. Several installations on pipe type electric cables after 8 to 10 years are reported to indicate that the initial high insulation values have decreased relatively fast, and have reached a level of about one-hundredth of the initial resistance, due to the absorption of water from the soil."

Natural asphalts were used by the ancients as far back as 2600 B.C., and is represented as proof that asphalt produced today from crude oil will give outstanding performance as a protective coating for pipelines.

These natural asphaltic substances through some geological accident were forced to the surface mixed with soil particles (silicas and clay), and are found as outcroppings. Normally they are referred to as malthas, or natural asphalts, such as Trinidad Lake asphalts. Eminent geologists believe these substances were forced to the surface as the result of

FIG. 7

FIG. 8

earthquake, or volcanic action, and are largely sulfonated by sulfuric fumes or acids released during these disturbances, together with heat and pressure to produce many varieties or variations, as found in outcroppings throughout the world.

These malthas and asphaltites may have performed a function aboveground for paving, the production of statues, building materials, or the compounding of "Greek Fire"; however, archeologists only find traces of these natural products for cementing masonry, when excavating underground structures, and then only in desert areas, mostly in the Asian countries. Herodotus, 5th century B. C. Greek historian, described in great detail "the walls of the City of Babylon, built of bricks baked in kilns, cemented with lumps of bitumen found in a small stream, the Is, which flows into the Euphratus, and interposing a layer of wattled reeds at every thirteenth course bricks."

Little evidence remains today that would indicate underground performance, equivalent to pipeline levels or ditch bottoms, as they were used in extremely arid regions under such circumstances that the materials were out of contact with moisture, and in some cases not even exposed to open atmospheric conditions. In other areas where moisture was present, these substances disintegrated due to moisture absorption, because of their soil or clay content.

Geological finds of these solids in their normal state contain from 10 to 30 percent water, and one company in the United States produced a product in the period from 1915 or 1916 to approximately 1935, by the use of a blend of water free-lake asphalt with coal-tar pitch in a ratio of approximately 30 percent asphalt to 70 percent coal-tar pitch, plus a silica filler. By blending the dried product with coal-tar, the water resistance was probably due to the fact that

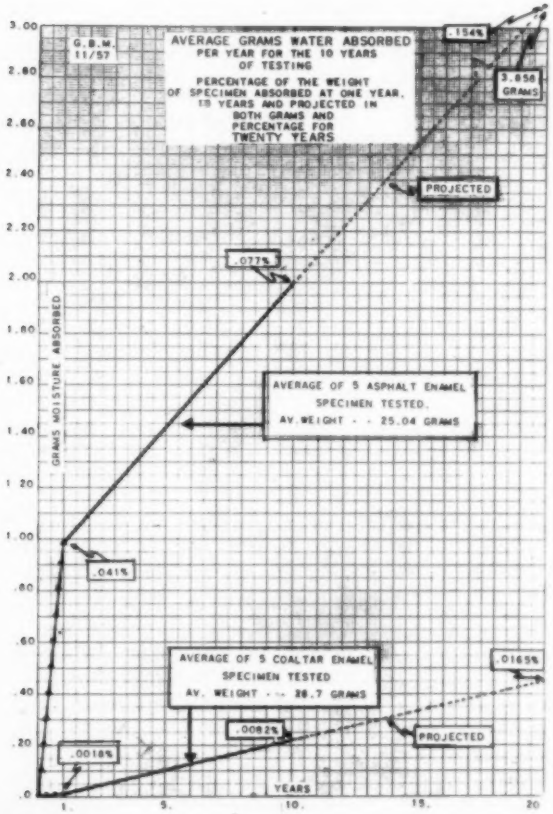

FIG. 9

FIG. 10

the coal-tar pitch being the predominant factor, its water resistance fortified to a limited extent the lake asphalt. (See Fig. 10, Part 1 of this series.)

The use of these natural asphalts was dropped from pipeline coatings largely because of the introduction of higher flexible coatings made from coal-tar pitch, and because of the high import price of lake asphalts delivered in the United States.

Asphalts produced from crude petroleum were introduced approximately in 1900. About 1920 there were attempts to produce blends of air blown asphalts and coal-tar pitch for built-up-roofing on steep surfaces, pipeline enamels, etc. These were not successful because of the incompatibility of the two substances, based on the difference in molecular structure. Asphalts produced from domestic crudes are mostly aliphatic in nature and made up of straight and branched chains together with saturated naphthenic rings and other ring types. These blends sludged or precipitated portions of the coal-tar pitch, which has an aromatic fused ring type of structure.

From more than 30 correspondents we have received comments similar to the following examples. ". . . Corrosion occurring underneath poorly adhering asphalt coatings, and not responding to cathodic protection, has frequently been observed; in several instances the corroding surface underneath the non-adhering coating was moist, even though there had been no rainfall in the area for more than two years. It is our opinion the moisture is breathed through the non-adhering coating and condenses on the pipe surface because of low night time temperatures, and also the moisture passes through the coating under electro-endosmotic effect . . ."[6]

". . . Five years after cathodic protection was continuously applied, where the soil-to-pipe potential was found appreciably lower than adjoining sections, the pipe was excavated and the coating inspected . . . stripping sections of the coating revealed no bond and considerable moisture between the pipe and coating . . . a sample of this brown liquid was found to be a basic solution containing 17 percent sodium carbonate with a pH value of 11.5 . . . some other areas between the coating and pipe contained a white deposit, crystals, apparently of the same substance . . . this apparently was the result of moisture penetration of the asphalt coating and wrapping used . . ."[7]

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[1] Clyde L. Carter, "Soil Temperature, Moisture Content, and Thermal Properties," Bulletin 15, June 1951—Engineering Experimental Station, University of Tennessee.
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[3] Correspondence, Soil and Water Conservation Research Branch, U. S. Dept. of Agriculture, Tucson, Arizona, August 1957.
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[5] G. R. Olson, "A 17-Year Cathodic Protection Program Has Paid Off," *The Pipeline Engineer*, December 1956.
[6] Correspondence, L. P. Sudrabin, Electro Rust-Proofing Corporation, November 1956.
[7] F. M. Massry, "Control of External Corrosion on Trans-Arabian Pipeline," NACE Annual Conference, March 1957.

★ ★ ★

E. S. Murray
Vice President and General Superintendent
Tennessee Gas Transmission Company

SAFETY in GAS TRANSMISSION OPERATIONS

How Tennessee Gas organized its safety program and what it gained

IT IS A PRIVILEGE to appear before this group of experienced operators who are dedicated to this vital problem of elimination of accidents and incidents that cause loss of life and property damage in our industry. I realize that this contribution will not provide a cure-all or even a shortcut to a quick and satisfactory solution of this ever-present problem. With your indulgence then, I will endeavor to show how one young company has approached the problem hoping that you may find something worthy of your time and attention.

To establish a setting, I call to your attention that we operate in several states, in different climates, and among people of different habits and customs. Hence, any program must be adaptable to these various conditions. Also, ours is a new company, being in existence only 14 years, and our employees are not concentrated in large numbers. Our field activities are in rural areas in district units seldom having more than 100 employees in the district. Two-thirds of our employees work shift on a basis of 40 hours per week. In passing, more than 90 percent of the employees are stockholders and many live in company houses at their district headquarters where the hazards of camp life must be included in the overall accident prevention program.

Additionally, the material, the procedure, and the conclusions presented herewith pertain to the gas transmission portion of Tennessee Gas Transmission Company, commonly called the Operating Department, and do not include production, refining, sales, or main office personnel. A few statistics will complete the picture and set up a basis for your comparison.

There are approximately 2150 employees distributed along our pipeline system, divided among 43 operating districts and the Houston office. There are approximately 10,000 miles of main transmission lines and 600,000 installed horsepower so arranged as to transmit approximately 2¼ billion cu ft of gas per day from sources along the Gulf Coast and from underground storage to the markets in the Ohio Valley and farther east to the Atlantic Coast.

Finally, our operational arrangement is one of effective simplicity; sometimes not possible in larger and older organizations. W. C. McGee, Jr., vice president, is in charge of operations. He reports directly to Gardiner Symonds, president of the company. Under a vice president and general superintendent with adequate assistants, the operating details are divided and allocated according to type of work and skill required.

After a period of experimentation and study during those years of maximum rate of company growth it became evident that if we were to achieve and maintain the desirable high standards of operation and employee welfare, an aggressive campaign was indicated. Our management decided the rewards would be well worth the financial expenditures.

Realizing that guidance and specific instruction must originate at the top, and that only active participation by each individual would insure the maximum of personal interest and enthusiasm, we designed our campaign to make individual safety and elimination of accidents a way of life for each employee and members of his family. Continuing on the theme that management does have an obligation of being continuously sensitive to the health, happiness, and welfare of the employees, we set out to build a program suitable to our specific needs from the ground up, using all the best techniques and experiences we found available after an extensive survey.

What the Basic Facts Were

After careful analysis we found that there are several basic facts applicable to our particular operation. These are presented here, with the realization that there may be some differences in opinion. We offer them for consideration rather than as points of controversy. We believe and practice the following:

First: Leadership and enthusiastic guidance must come from the top. Few classes or groups of students excel their teachers.

Second: All of our employees are willing and anxious to do what they think they are expected to do. Management's obligation, then, is one of proper instruction.

Third: Operational and educational methods must be kept up-to-date and in keeping with the specific situation. Management must not become inattentive to changes or permit stagnation by using obsolete rules and practices.

Fourth: Our employees have latent skills and unlimited mental curiosity,

Presented before National Safety Congress and Exposition, Chicago, Illinois, October 22, 1957.

vital ingredients in any self-improvement campaign. Management must arrange to fully utilize these contributions already on hand.

Fifth: No one man or small group of men can be assigned to do all of the things needed to eliminate accidents and loss of life and property along our widely scattered system.

This Was the Program Adopted

After the situation was evaluated the following procedure was approved and put into operation:

1. Provide a course of instruction covering the basic principles of gas and its transmission and uses. Make this course available to all employees of the operating department. This course of study does not deal directly with accident prevention; however, from the standpoint of safety, it has had an indirect and collateral effect. We feel that the best informed employee is also the safest employee. The more he knows about the operation of our system and the tools and materials used in that operation, the better able he will be to apply the techniques set out in our safety program.

2. Provide an opportunity for the employees of each operating district to continue in their quest for information after the original course of instruction has been completed.

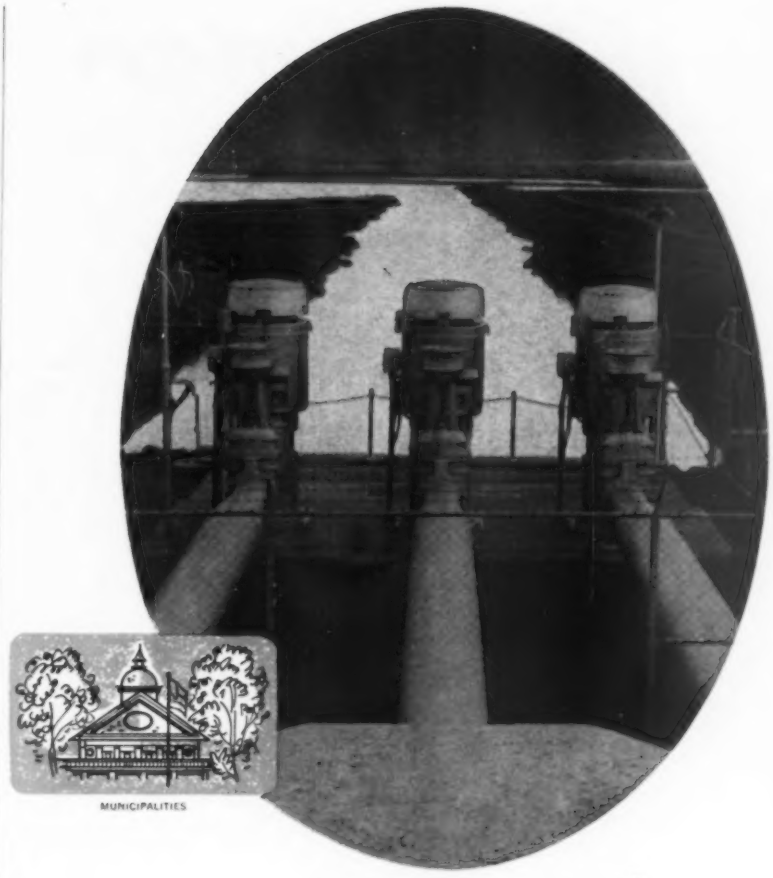
3. Provide simultaneously an opportunity for all employees to participate in a specific program applicable to their location and climatic limitations, designed to assist them in developing a better and safer way of life.

This program is now in effect throughout the extent of our entire transmission system and it is a pleasure to interject a comment at this point to the effect that the individual response and results have been quite gratifying. Briefly, the program incorporates the use of several units in the company organization and it operates in a flexible manner that allows for differences in locale, weather, temperament, and number of people involved.

Basic Education and Instruction

With the assistance of the Extension Service of the University of Texas, a course called "Fundamentals of Gas Transmission" was developed to be given to all employees in Texas by holding classes at headquarters of the various districts. This is a 60-hr course made up of four parts requiring 3 hours per day for 5 days per week for four weeks. Duplicate classes usually were held in order to accommodate the off-time hours of the shift men and visitors.

Fifteen hours, or one week, were given to each of the following four main classifications:



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The size of this undertaking may be best evaluated by realizing that this course will provide 60 hours of lecture room attendance for approximately 2500 employees scattered across more than 2000 miles of the transmission system, at approximately 50 different class rooms.

Inasmuch as the personnel from the University of Texas could not leave the state without additional cost and for other reasons, we developed our own instructors for the remainder of the system, utilizing personnel from our operations, engineering, industrial relations, research, and accounting departments. The problem of obtaining enough skilled instructors retarded progress until we had trained our own employees to take over.

At this point we brought into action the industrial relations department by requesting help from their personnel who are familiar with safety and training techniques. They helped us by selecting and outlining materials; with visual aids as well as the preparation and scheduling of instructors.

Using our own people as instructors and organizers we found that when properly coordinated under the direction of the staff of the industrial relations group it was a fairly simple task to route the course to various locations on a workable schedule.

The program is based upon the concept that our employees are just as interested in the progress and success of the company as management and that they can be trained to do all the tasks needed to maintain that progress and success, within the limits of their activity.

To that end, then, we set up a procedure incorporating these guiding principles.

Attendance is not mandatory, the employees receive no extra pay, they attend on their own time, and they are not criticized for nonattendance. Response to this program was amazing to management. It was so great that we have been able to cut in half the time originally allocated for completion. We are now making an effort to complete it by early 1958.

Briefly the course uses graphs, moving pictures, industrial booklets, photographs, and visual models, all screened to eliminate loose or rambling com-

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mentary or irrelevant materials. The goal of instructors is one of bringing data pertinent to the jobs and lives of employees and presenting it in a manner to maintain the interest of the audience. Down-talking or any type of presentation beyond good common sense is forbidden.

Activation of this first portion of the overall program created other problems. With but few exceptions after finishing the course, employees requested and even demanded a continuation of some form of instruction. They were mentally hungry for more details concerning their jobs.

A Second Program Adopted

Accordingly then, Part 2 of the general program was activated in the form of a schedule of monthly operating meetings to be held at each district headquarters largely on company time, making it mandatory that supervisors and foremen especially attend. Here again, the response was very gratifying. This was done by using the time previously given to safety meetings to what we now call operating meetings. Safety, as such, is given a fair quota of time but any other worthy subject chosen by the employees at the district headquarters is woven into the programs. These meetings are under the leadership and are part of the duties of a district supervisor, either from pipeline or compressor departments. Each group makes up its own program in advance, usually 2 or 3 months ahead of date of presentation.

Houston office provides guidance, instructors, and films, as needed and upon request. In some instances, after consultation with the field supervisor, minor changes have been made to broaden the scope and eliminate repetition, which might lead to lack of interest.

Management urges the field supervisors to operate these programs as a school and to be on the alert to present current and useful topics. Examples of subjects presented at these operating meetings include maintenance and testing of plug valves; actual on-the-job operation of a plant emergency shutdown system; company thrift plan and retirement benefits and other personnel policies, and discussions by local highway patrol supervisors.

Meetings on safety in the home and safety in school buses have been combined to form a family night, with refreshments and a period of questions and answers, aimed at full cooperation with local civilian defense, law enforcement, fire prevention, and highway patrol officials. Personal income and property tax problems also have been discussed at these family night meetings.

These are a few of the highly regarded categories. More are being developed as the programs become more firmly fixed in the minds of those who arrange as well as attend the meetings.

Using the well-known and ever-useful technique of Sunday Schools and other community activities, whereby everyone participates by being given an assignment or a part to play, it has not been difficult to maintain a high degree of enthusiasm at these field-controlled meetings.

Management must be alert to the fact that these meetings provide a sounding board often operating two ways, a desirable feature in maintaining any type of communications.

Supplementing the educational course and the monthly operating meetings, our company operates a research laboratory in Houston, arranged to serve the needs of the entire company. This institution is called upon to provide data pertinent to all forms of mechanical failures, such as pipe and crankshaft failures, corrosion, mechanical performance of equipment, and engine analysis.

Visual Aids Important

We have found that visual aids in the form of models, actual samples, slides and moving pictures of chosen techniques and materials are most valuable. Following the theme that safety in the home, on the road and on the job can be incorporated into a way of life for every individual, we provide moving pictures applicable to the program of the moment. We use films of other agencies and also make our own moving pictures of special company projects. These films have many uses: (1) For record purposes, (2) for public relations, and (3) for employee interest and education.

We have several films with sound and color made by company employees and available for these field meetings. One in particular has been shown repeatedly, "Emergency Shutdown at Compressor Stations." This film vividly portrays what can happen at a station and our method of minimizing the effects. To date we have eight company-made films, all on company subject matter made by company personnel at familiar locations. Propaganda as such has been eliminated, as there is an ample supply of factual data available for many films. Many copies of our films on corrosion control have been made and are in use by other companies. Films on our Muskrat Line and offshore gas gathering system construction in the Gulf of Mexico are particularly interesting to our own employees and a full house is guaranteed at every showing.

Finally, in rounding out the program, each district has been set up as a unit and the performance of each district can be rated in competition with other units. A safety flag is allowed to be flown as long as there are no lost-time accidents in the district. Special awards from the Southern Gas Association and the Holmes Awards are presented and are on display wherever earned. Log books are kept at the district office as guides and records of past and future meetings.

Every effort has been given to keeping the interest and enthusiasm focused at the district level and to eliminate any feeling on the part of field employees that there is someone in the Houston office who will do their safety work for them, or that they are lucky and not in need of constant attention to their own welfare. This approach is not in opposition to national campaigns on health, civilian defense, highway behavior, Red Cross, and united charity drives; hence not in conflict with national thinking. As our people are good citizens in all of these ventures we know that they can develop and carry on a campaign of their own, particularly when their lives, their jobs, their health, and their families are directly involved. Thus we see that the rewards for a better way of life are great for each individual.

How Does the Company Gain?

Now, how does the company's interest fare in this mutually motivated effort? Briefly, let us look at the record. In 14 years of operation we have had no major fire or disaster in our stations. Pipeline failures have been at a minimum and in no instance could an employee be charged with negligence or ignorance. Being more specific, according to the National Board of Fire Underwriters, the average loss ratio for the gas industry is 41 percent for the period 1947 through 1955. This means 41 percent of the premiums paid in by the industry are paid out in claims.

We are indeed proud of our record, for only 6.47 percent of our total premiums have been paid out in claims.

Although the value of a human life should never be calculated in dollars alone, we all realize that in saving lives we certainly save dollars, thus you have your choice to be right on two counts.

In closing, we have learned and we operate on the theme that elimination of accidents and a resulting better way of life can be attained throughout our company if every one makes a contribution to the common goal. The key to the entire project is one of education and training — the same key to the remarkable growth and achievements of the entire American industry.

★ ★ ★

Pipeline Projects

Gulf Interstate Gets OK on $51,000,000 Project

The Federal Power Commission has granted Gulf Interstate Gas Company temporary authorization to construct natural gas facilities costing approximately $51,000,000, in Louisiana, Mississippi, Tennessee, and Kentucky.

Gulf Interstate proposes to construct about 351.7 miles of 30-in. main line loops and about 54 miles of 24-in. lateral line loops. In its application, Gulf Interstate said that at present its authorized design capacity is 575,000,000 cu ft daily. Beginning in November 1958 its present facilities will be inadequate to transport the volumes requested by its sole customer, United Fuel Gas Company, of Charleston, West Virginia, the company said. In January, February, and March 1959, United Fuel requirements will be about 662,000,000 cu ft per day, the application stated. The additional facilities, Gulf Interstate said, would increase its maximum winter delivery capacity to 666,100,000 cu ft daily.

The temporary authorization was conditioned by the FPC to provide that construction of the proposed facilities shall not begin until Gulf Interstate's plan of financing is submitted to and approved by the commission.

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Cherokee Embarks On $5,500,000 Program

A $5,500,000 pipeline expansion program, including construction of a new 12-in., 87-mile products line from Ponca City to Glenpool near Tulsa and conversion of an existing crude line from Glenpool to Wood River, Illinois, is announced by Cherokee Pipe Line Company, Ponca City, Oklahoma.

Cherokee Pipe Line Company is owned by Continental Oil Company and Cities Service Pipe Line Company.

Organized in 1954, Cherokee now owns a products line extending from Ponca City to Wichita, Kansas, and to Oklahoma City and Wood River. Cherokee also has a crude oil gathering system in Oklahoma with a crude oil trunk line extending from Central Oklahoma to Wood River. The crude oil trunk line will be converted to products service and will connect with the new 12-in. Ponca City-Glenpool line.

Also included in the expansion project are new pump stations at Afton, Oklahoma, and Richland, Missouri, and additions to existing stations at Ponca City and Glenpool and at Mount Vernon and Belle in Missouri. When completed this fall, the Cherokee system will have a total capacity of 60,000 bbl of petroleum products daily.

Lateral Line Allowed In Pecos County, Texas

Permian Basin Pipeline Company has been granted authority by FPC to construct 26.8 miles of 10-in. lateral pipeline from a point on its existing system in Pecos County, Texas, to a gasoline plant owned by three independent gas producers, also in Pecos County. The facilities will be used by Permian to purchase and receive residue gas from the producers at the outlet side of their Imperial No. 2 gasoline plant.

Projects

Gas Storage Scheduled for Ambassador Field, Texas

Lone Star Gas Company has applied to the Federal Power Commission for authority to construct an 880-hp compressor station and other facilities to store natural gas in the Ambassador field of Clay County, Texas.

The company said the project, estimated to cost approximately $740,000, would enable it to more efficiently serve its present customers in Wichita Falls and other local distribution systems in the Wichita Falls area. The underground storage reservoir would permit the storage of gas during off-peak periods for withdrawal during peak-consumption periods, the Lone Star application states.

The Ambassador reservoir is a partially depleted oil field located about 20 miles southeast of Wichita Falls. Gas to be stored would come primarily from Oklahoma sources through Lone Star's pipeline system. Traversing the Ambassador field, a 25-mile, 12-in. diam line from Lone Star's New York City gas storage field in Clay County would deliver the Ambassador field storage gas to Wichita Falls and other distribution systems.

Lone Star estimates that gas storage in the 174-acre Ambassador field will result in recovery of an additional 472,907 bbl of oil and after recovery of this oil the storage reservoir will have a capacity of approximately 2,559,525,000 (billion) cu ft of gas. Cushion gas to the extent of 993,000,000 (million) cu ft will be required, resulting in a working storage capacity of about 1,566,525,000 (billion) cu ft.

Construction of the Ambassador field gas storage facilities is schedule to get underway shortly after Federal Power Commission approval. In November the Railroad Commission of Texas authorized Lone Star to store gas in the Ambassador field.

Permian to Turbocharge Andrews Station Units

Permian Basin Pipeline Company has been authorized by FPC to acquire, construct, and operate natural gas facilities in Andrews County, Texas, at an estimated cost of about $897,400.

Permian will acquire an existing 1350-hp compressor unit, located at its Andrews County station, from Phillips Petroleum Company.

Permian also was authorized to turbocharge 6 of the 12 units presently in operation at the Andrews station, which, with the new unit, will provide an increase of 4050 hp and a total installed horsepower of 20,250.

United Plans Boost to New Orleans-Mobile Line

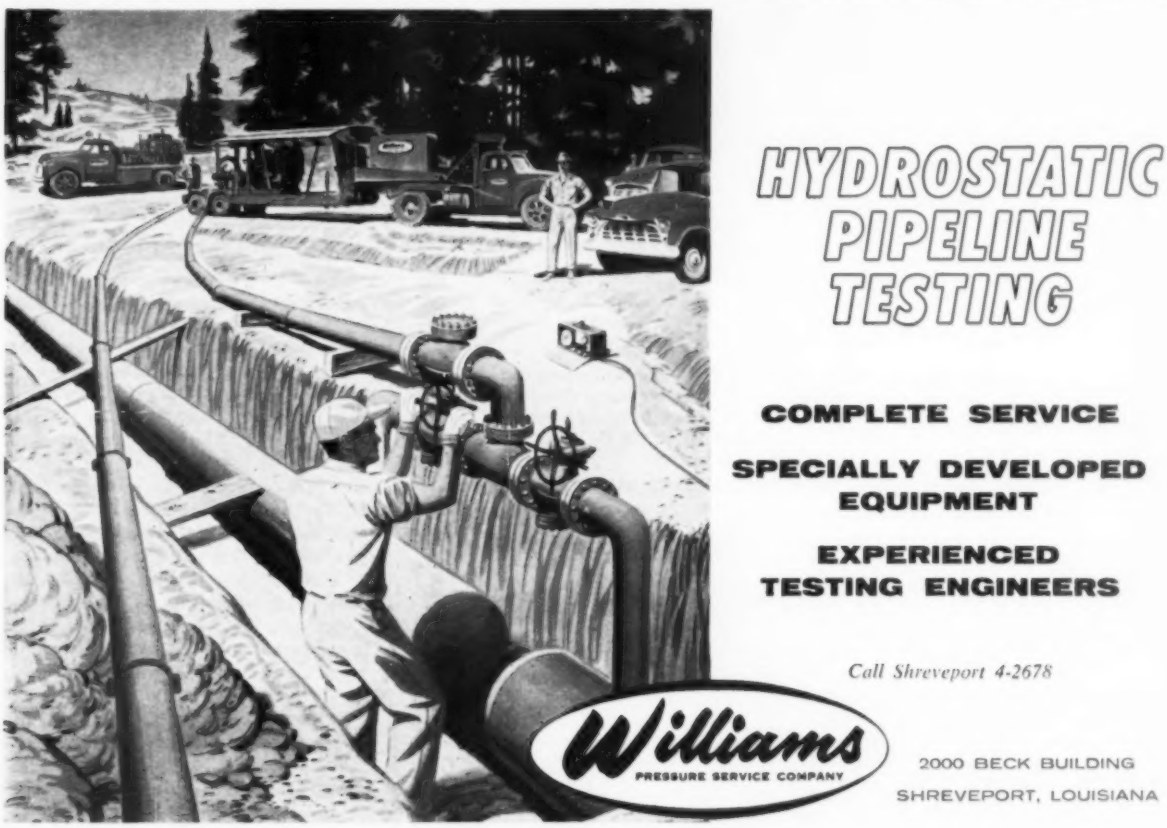
United Gas Pipe Line Company has applied to the Federal Power Commission for authority to build approximately 203 miles of 30-in. natural gas pipeline paralleling an existing line between New Orleans, Louisiana, and Mobile, Alabama.

The project would be constructed in two phases, the first including 78.7 miles of line from a point near New Orleans to a point in Hancock County, Mississippi, and 38 miles from a point in Harrison County, Mississippi, to a point in Jackson County, Mississippi. The second phase would include a total of 86 miles of pipeline paralleling sections of the company's southeast Louisiana-Mobile line.

Gulf Interstate's Request Granted by Commission

The Federal Power Commission has issued a certificate to Gulf Interstate Gas Company authorizing the construction and operation of natural gas pipeline facilities in Jefferson Davis, Vermilion, and Cameron parishes, Louisiana.

The project includes 9.9 miles of 20-in. loop line in Jefferson Davis and Vermilion parishes and 2.9 miles of 6-in. loop line in Cameron Parish.



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Laurel Pipe Line Awards Construction Contracts

Laurel Pipe Line Company, formed last spring to transport gasoline and other petroleum products from refineries in the Philadelphia area to Cleveland, Ohio, and intermediate points, has awarded construction contracts. The 440-mile line will be 24 in. in diam, between Philadelphia and Harrisburg, the largest ever built for petroleum products. Following are the awards by sections:

Section 1. From Eagle Point, New Jersey, to the west bank of the Delaware River, including the Delaware River crossing, consisting of 5.6 miles of 24-in. line, awarded to Missouri Valley Dredging Company, Omaha, Nebraska.

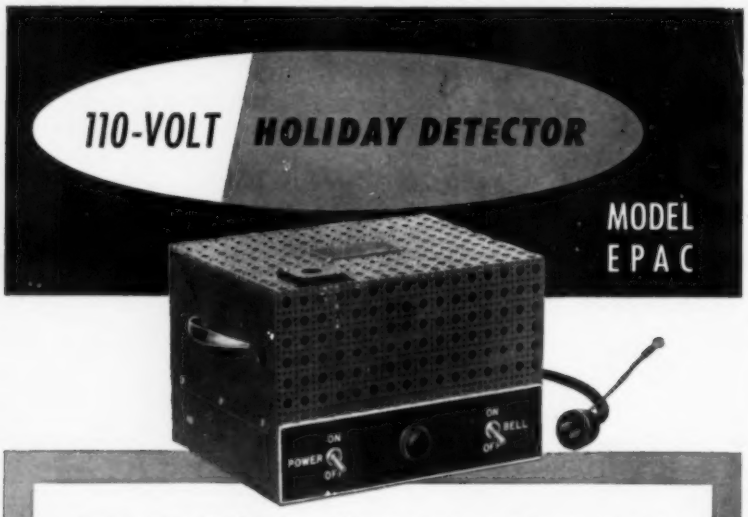
Section 2. From the west bank of the Delaware River to Laurel's Booth station site in Delaware County, Pennsylvania, consisting of approximately 20 miles of 24-in. line awarded to Missouri Valley Dredging Company, Omaha, Nebraska.

Section 3. From Booth station to Mechanicsburg station near Harrisburg consisting of approximately 106 miles of 24-in. line, awarded to Engineers Limited Pipeline Company, San Francisco, California. The Susquehanna River crossing and approaches consisting of one mile of 24-in. line were previously awarded to Pipe Line Construction and Drilling Company.

Section 4. From Mechanicsburg station to Duncansville station consisting of approximately 78 miles of 20-in. line, awarded to Panama, Inc., Houston, Texas.

Section 5. From Duncansville station to the Aliquippa station in Beaver County, Pennsylvania, 113 miles of 18-in. line, awarded to Panama, Inc., Houston, Texas. This section includes crossings of the Allegheny and Ohio rivers.

Section 6. From Aliquippa station to Cleveland consisting of approximately 106 miles of 14-in. line, awarded to Williams Brothers Company, Tulsa, Oklahoma. Construction is scheduled to begin in April.



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Big Northern Ontario Project Starts in May

One of the largest composite pipeline construction programs ever undertaken in Canada will be in progress by the first of May for Northern Ontario Natural Gas Company, Ltd., which plans to construct 825 miles of lines, exclusive of services, for the 33 communities for which it has franchises to distribute natural gas in northwestern and north central Ontario. Northern will take all its gas from the Trans-Canada main line.

Total expenditure is estimated at $15,000,000. Tenders will be called for March 15 and contracts awarded by April 1. Major laterals will be an 86-mile 16-in. line from North Bay to Sudbury to serve this nickel smelting city and the International Nickel smelter, and a 32-mile line to the mining community of Timmins.

The project also includes systems in all cities and towns along the routes of the Northern Ontario Crown and Trans-Canada main lines east of Kenora as far as Orillia, through the pulp, paper, and metal mining regions. An advance contract in Kapuskasing, junction point of the Crown and Trans-Canada lines, is 90 percent complete, with 80,000 ft of lines laid.

Fish Service Corporation, of Regina, has been engaged as construction supervisor for the entire project. It has established regional headquarters at North Bay and Timmins.

Construction under carried-over 1957 contracts in Kenora, Dryden, and the Lakehead cities will resume as early as possible in the spring. Scheduled completion date for the whole system is November 1, 1958.

Service Awards Contract For Microwave Towers

Service Pipe Line Company has awarded a contract to the Tower Construction Company, Sioux City, Iowa, to construct a chain of nine microwave towers, ranging up to 420 ft in height, across parts of Missouri and Illinois. The towers will be erected at Edina and Medill in Missouri, and East Ft. Madison, Ormonde, Laura, Campgrove, Streator, Verona, and Manhattan in Illinois.

G. L. Maciula, chief engineer of Service Pipe Line Company, said work started on erecting the tower at Edina, northeast of LaPlata, Missouri, on February 24. The new system will connect with an existing microwave system at the company's LaPlata pump station, and will continue across Illinois to its Manhattan station. The route follows the company's trunk system to refineries in the Chicago area.

Initially, the microwave system will be equipped to handle 10 voice channels, Maciula said. Operating data and other information gathered at the stations will be transmitted to a dispatching center at Freeman, Missouri.

The nine microwave stations in the system will operate in the radio frequency band of 6700 megacycles under authority of the Federal Communications Commission.

The new system, due for completion in the fall of 1958, will be under the supervision of J. J. Willenburg, Galesburg division manager of the Missouri-Illinois division for Service Pipe Line.

When it is completed, unattended electric pump stations at Medill, Ormonde, and Streator will be controlled from Freeman.

El Paso Gets Temporary Permit for Facilities

The Federal Power Commission has granted El Paso Natural Gas Company temporary authorization to construct 21.4 miles of 10¾-in. pipeline extending from Santa Rosa Gas Company's proposed Fort Stockton compressor station to Pecos Company's existing processing plant, all in Pecos County; 18.4 miles of 8⅝-in. from the Pecos plant to a point in Ward County and additional metering facilities at the Pecos processing plant.

In its application, El Paso stated that the facilities were necessary to enable it to purchase residue gas, which is presently being flared, from Santa Rosa. El Paso says it has contracted for approximately 10,000,000 cu ft per day of residue natural gas during the first year after delivery is begun and about 14,000,000 cu ft daily thereafter.

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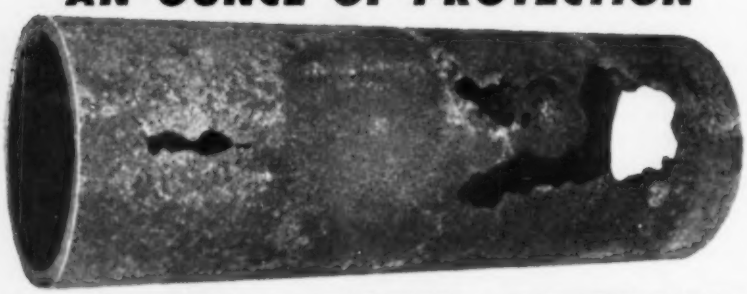

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1	Primer	Primer	Primer	Primer	Primer	Primer	Primer
2	2/32" Enamel	2/32" Enamel	2/32" Enamel	2/32" Enamel	2/32" Enamel	2/32" Enamel	2/32" Enamel
3	1/32" Enamel	Glass	Glass	1/32" Enamel	1/32" Enamel	1/32" Enamel	1/32" Enamel
4	Asbestos Felt	1/32" Enamel	1/32" Enamel	Asbestos Felt	Glass	Asbestos Felt	Glass
5	Kraft	Kraft	Asbestos Felt	X or Seal Coat Enamel	X or Seal Coat Enamel	X or Seal Coat Enamel	X or Seal Coat Enamel
6			Kraft	Kraft	Kraft	Asbestos Felt	Asbestos Felt
7						Kraft	Kraft

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Projects

New York State Natural Given FPC Approval

The Federal Power Commission has authorized New York State Natural Gas Corporation to construct and operate natural gas facilities estimated to cost approximately $7,002,800, in Pennsylvania and New York.

New York Natural proposes to replace its 56.5-mile, 20-in. No. 1 line extending from its Boom compressor station in Tioga County, Pennsylvania, to Ithaca, New York, with 30-in. line over a period of four years and to install an additional 2000 hp at Boom.

In its application, New York Natural proposed replacement of 12 miles of line in 1955, 17 miles in 1956, 14.6 miles in 1957, and 12.9 miles in 1958. The additional compressor horsepower was proposed for 1955. The FPC, in August 1955, June 1956, and April 1957, granted New York Natural temporary authorization for the construction and operation of all but the 1958 facilities.

Laying Gas Gathering System in 55 Ft Water

Work on a 10-mile gas gathering line in the West Delta area about 18 miles from the Louisiana Coast for Tennessee Gas Transmission Company has been started by Commonwealth Oil Company.

The line is being laid by the "Magic," Commonwealth's pipelaying barge.

The new line, all of 12¾-in. concrete-coated pipe, will interconnect gas wells of the Continental Oil Company in Louisiana offshore blocks 54, 58, and 59 with a Tennessee Gas line extending to the mainland in the West Delta area.

Location is approximately 20 miles south of Venice, Louisiana, the base of operations for the pipelaying project. The line is being laid in water approximately 55 ft deep and in trenches ranging from 6 to 10 ft deep, which will be backfilled.

Budget-Type Request Granted

The Federal Power Commission has authorized Texas Eastern Transmission Corporation and its subsidiary, Wilcox Trend Gathering System, Inc., to construct natural gas facilities during 1958 at an estimated cost of approximately $4,000,000.

Texas Eastern was authorized to construct facilities not to exceed $3,000,000, with no single project exceeding $500,000. Wilcox was authorized to construct facilities not to exceed $1,000,000, with no single project exceeding $150,000.

The companies stated that their applications were of the budget-type.

PIPELINE PERSONALS

Jac A. Cushman, formerly assistant director of public information, has been promoted to corporate secretary and convention manager of the American Gas Association. He succeeds **Harold S. Walker Jr.,** who has been named assistant to the managing director.

James G. Elliott has been promoted to superintendent of right of way for the 9-state area in which Texas Gas Transmission Corporation pipelines are located. **M. E. Bless,** now of Memphis, Tennessee,

J. G. Elliott

M. E. Bless

and **W. T. Turner Sr.,** Monroe, Louisiana, were named division superintendents of land and lease. Bless will soon be located at Owensboro where he will supervise Texas Gas pipeline right of way activities in Kentucky, Illinois, Indiana and Ohio. Turner will continue to be located at the company's Monroe offices where he will be responsible for pipeline right of way in Tennessee, Mississippi, Arkansas, Louisiana and Texas. Elliott, a 21-year employee of Texas Gas, was division superintendent of land and lease. **Burvil Taylor,** of Monroe, and **Truman D. Barnes Jr.,** of Memphis, have been appointed to the district manager positions formerly held by Turner and Bless.

W. T. Turner Sr.

W. E. Biery

Walter E. Biery has been named president of the Mid-Continent Pipe Line Company succeeding **J. Marston Linehan,** who resigned to become vice president and manager of crude oil supply and transportation for Sunray Mid-Continent Oil Company and D-X Sunray Oil Company, its refining and marketing subsidiary.

Linehan, identified with the pipeline company since 1933 successively as division superintendent, general superintendent, vice president and general manager, has served as president of the transportation unit since 1947. A special meeting of Mid-Continent Pipe Line stockholders accepted the resignations of Linehan, **R. W. McDowell, R. Paul Henry,** and **R. H. Wills** as board members and named Biery, **O. E. Bryant, Fred E. Pyeatt Jr., M. C. Jones,** and **J. H. Woodard** as successors. The new directors then elected Biery president and chairman of the board; Bryant, vice president; B. P. Lambert, secretary-treasurer, and Woodard, assistant secretary-treasurer. Bryant is manager of MCPL field operations; Pyeatt is manager of engineering, and Jones is manager of crude oil traffic. Lambert and Woodard are officers of D-X Sunray, of which MCPL is a wholly-owned subsidiary.

L. L. Whiteneck, vice president and director of materials research for Plicoflex, Inc., Los Angeles, California, has been elected president of the National Association of Corrosion Engineers. Also elected were **Hugh P. Godard,** head of the chemical division, Aluminum Laboratories, Limited, Kingston, Ontario, Canada, vice president and **A. L. Stegner,** corrosion engineer for Tennessee Gas Transmission Company, Houston, re-elected for a second term as treasurer.

Raymond F. Hadley, chief engineer of the product lines department of Sun Pipe Line Company, has been appointed to the additional post of vice president. Hadley's pipeline career began in 1931 for Susquehanna Pipe Line Company. In 1951 Susquehanna Pipe Line and other pipeline subsidiaries of Sun Oil Company were merged into a single organization—Sun Pipe Line Company, and in 1954 Hadley was named chief engineer.

R. F. Hadley

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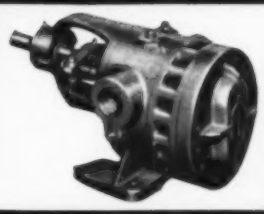

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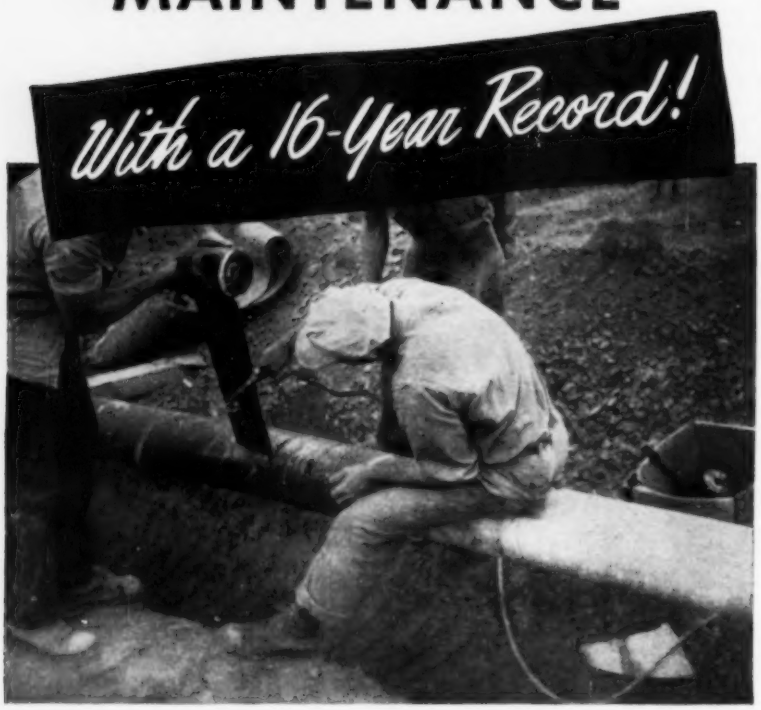

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Personals

▸ **W. R. Stephens** has been elected president of Arkansas Louisiana Gas Company succeeding the late J. C. Hamilton. Stephens has been chairman of the board of Arkansas Louisiana since January 1957, and will continue in that position, also. **D. W. Weir,** of Shreveport, was named to the newly created position of executive vice president and elected to the board of directors of the company. **Lindsey Hatchett,** of Little Rock, also was elected a new vice president of the company. Weir previously has served as a vice president and Hatchett has worked on special assignments for ALG for several years.

▸ The promotions of **Wilson N. Gilliat,** chief engineer, to assistant vice president-engineering, and **Charles J. Flint,** assistant chief engineer to chief engineer, were announced by Williams Brothers Company, Tulsa.

W. N. Gilliat

C. J. Flint

▸ The 1957 NACE Willis Rodney Whitney Award will be given to **T. P. Hoar,** lecturer in metallurgy, Cambridge University, England. The Frank Newman Speller Award will go to **Robert J. Kuhn,** for more than 30 years corrosion engineer for New Orleans Public Service, Incorporated, New Orleans, Louisiana. The awards will be presented during the annual banquet of the National Association of Corrosion Engineers, March 19 at San Francisco. The banquet will be held during the NACE 14th Annual Conference and Exhibition, March 17-21, 1958.

▸ **Paul Fink,** Bradfordwoods, Pennsylvania, has been appointed chief mechanical engineer for The Peoples Natural Gas Company. Fink, with the company since 1951, has had various responsible assignments, including the designing of compressor stations and the overseeing of construction work.

▸ **Ralph P. Paden,** formerly assistant manager of the crude oil pipeline division, has been named manager of the division's technical section, and **Winfield S. Schmidt,** who was assistant manager of the company's products pipeline division at Philadelphia, is now manager of the crude division's operations section and has moved to Dallas, both for Atlantic Pipe Line Company.

▸ **Ernest R. Shearer,** formerly assistant superintendent, Cygnet division at Lima, Ohio, has been appointed superintendent of the Midwest products division, Lima, for Buckeye Pipe Line Company. **Charles W. Tomford,** formerly superintendent of the Midwest products division has been appointed manager of the planning and development department, Lima.

▸ **Gordon C. Bowen,** secretary-treasurer, Algonquin Gas Transportation Company, Boston, has been elected to membership in the Controllers Institute of America. Established in 1931, the Institute is a non-profit management organization of controllers and finance officers.

WITH THE PIPELINE CONTRACTORS

● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 100 miles of 18-in. for *Alberta Gas Trunk Line Company, Ltd.*, from Burstall at the Alberta border to Provost, Alberta. Also has 22 miles of gas gathering line in the Provost field for *Provo Gas Producers, Ltd.*, consisting of constructing gathering system and wellhead tie-ins—3 to 12-in. pipe; this gas to be fed to Alberta Gas Trunk Lines.

● **Banister Construction, Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta.** Has undetermined amount of 2 to 6-in. extensions to existing systems in cities and towns in Saskatchewan, plus approximately 5000 consumer service connections, for *Saskatchewan Power Corporation*. Has contract for construction of transmission and distribution system in the town of Wilkie, Saskatchewan, for the *Saskatchewan Power Corporation*.

● **F. E. Shaw, Ltd., 530 S. Vidal Street, Sarnia, Ontario.** Has 40 miles of 6 to 10-in. line for *Dominion Natural Gas Company, Ltd.*, in the Brantford, St. Catharines, and St. Thomas districts. Has 67 miles of 6 to 20-in. transmission lines for *Union Gas Company*, Chatam, Ontario, to Dawn, London, St. Marys, Stratford, Kitchener and Guelph.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 212.5 miles 20-in. crude line for *Socony Mobil Oil Company de Venezuela*. Line will extend from San Silvestre field to Puerto Cabello on the Caribbean Coast. For *Laurel Pipe Line Company*, 106 miles of 14-in. from Aliquippa station, Pennsylvania, to Cleveland, Ohio.

● **Troth Construction Company, Box 592, Britton, Oklahoma.** Has contract for 160 miles of 2 and 8-in. lines for gas distribution to communities in the Aberdeen, South Dakota, area, for *Northern Natural Gas Company*.

● **Canadian River Construction, 580 Hornby Street, Vancouver, British Columbia.** Has contract on Spread Y, containing 91.3 miles of 30-in. gas line from Longlac to MP 584.8 at the east bank of the Shekak River for *Northern Ontario Pipe Line Crown Corporation*.

● **Williams-Austin Construction Corporation, 3322 Grant Building, Pittsburgh 19, Pennsylvania.** Has 50 miles of 10-in. for *Central Hudson Gas & Electric Company* between Kingston and Albany, New York. Also has 5.7 miles of 26-in. line for *Atlantic Seaboard Corporation* in Hardy and Grant counties, West Virginia.

● **Dutton-Williams Brothers, Ltd., North Canadian Oil Building, Calgary, Alberta.** Has 67 miles of 30-in. line for *Trans-Canada Pipe Line*. Has contract for 80 miles of gathering lines for *Westcoast Transmission Company's* natural gas grid system in the Peace River region; plans call for laying some 20-in. as an extension to the main line and also smaller diameter lines down to 6-in. for the Blueberry field.

● **Fish Service Corporation, M & M Building, Houston, Texas.** Has 67 miles of line for *Florida Pipeline and Storage Company* from Port Everglades to Homestead Air Force Base, Florida.

● **C. P. Bartley & Son Pipe Line Construction, P. O. Box 616, Tioga, North Dakota.** Has 121 miles of 2 through 12-in. gas gathering extensions for *Signal Oil & Gas Company* in the Newton, North Dakota, area.

● **Engineering-Construction Company, First National Bank Building, Tulsa, Oklahoma.** Has contract with *City of Macon, Missouri*, to lay 25 miles of 4 and 6-in. between Moberly and Macon, Missouri, and 12 miles of various size distribution lines in Macon.

● **G.E.T. Construction, Inc., 435 S. 116th St., Milwaukee, Wisconsin.** Has 46 miles of 24-in. loops in Wisconsin and Illinois for *Michigan Wisconsin Pipe Line Company*.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has 120 miles of 16-in. and 5 miles of 12-in. for *Magnolia Pipeline Company* from Midland to Abilene, Texas. Also has crossing of Neosho River at Chetopa, Kansas, for *Texaco-Cities Service Pipe Line Company*.

● **Four Way Company, Farmington Hwy., Aztec, New Mexico.** Has contract to lay 16-in. line for *Texas-New Mexico Pipeline Company*, for a distance of 150 miles southeast from the Aneth field in Southeast Utah.

● **Oklahoma Pipe Line Constructors, P. O. Box 13227, Dallas 20, Texas.** Has 35 miles of 30-in. for *Tennessee Gas Transmission Company* between a point in Garrard County, Kentucky, to a point of TGT's compressor site in Powell, Kentucky. Also has 85 miles of 20 and 24-in. (spread 101) of *Trans-Canada Pipe Lines, Ltd.*, on the eastern section, in proximity of Toronto, Ontario, beginning from a point southwest of Toronto circling the city, and also a section beginning at a point east or northeast of Toronto. Also has 100 miles of 30-in. for *Creole Petroleum Corporation* between Temblador and Caripito, Venezuela. This is the company's first Venezuelan venture since 1944. Has 50 miles of 22 and 24-in. loops for *Portland Pipe Line Corporation* and *Montreal Pipe Line Company;* 39 miles in U. S. and 11 miles in Canada. To start in spring.

● **Brown & Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has contract with *Texas Eastern Transmission Corporation* to furnish field supervision for construction of 626 miles of 30-in. loops along the company's line between Beaumont, Texas, and Uniontown, Pennsylvania.

● **Holder Construction Company, Box 1438, Snyder, Texas.** Has contract on 134 miles of 6-in. products line for *Trust Pipe Line Company* between Hawley and Wichita Falls, Texas.

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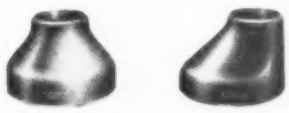

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Contractors

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has 26 miles offshore trenching for the *CATC Group* from Grand Isle, Louisiana, to a point 26 miles out into the Gulf of Mexico. Marine Gathering Corporation is the prime contractor, and Collins is burying the line being laid by Marine Gathering's pipeline barge. Has trenching contract for 57 miles of 12 to 26-in. lines running from shore to offshore facilities at Cameron, Louisiana, for *Tennessee Gas Transmission*. Has contract with *Accra-Mobil Overseas Oil Company* for 11,500 ft of 12-in. sea-loading line from shore at Accra, Ghana (Africa) to a depth of 50 ft. Also has 32,000 ft of 24 and 12-in. sea-loading line for *American Independent Oil Company* at Kuwait into the Persian Gulf. Has trenching contract with *Commonwealth Oil Company* for 10.6 miles of 12-in. offshore line in West Delta block in Gulf of Mexico.

● **Western Pipe Line, Inc., 1011 San Jacinto, Austin 66, Texas.** Has 94 miles of 30-in. for *Northern Ontario Pipe Line Crown Corporation* between Hawk Lake and Hyndeman, Ontario.

● **Panama Inc., 1418 Melrose Blvd., Houston, Texas.** Has contract for 362 miles of 16-in. for the *Texas-New Mexico Pipeline Company* from Jal, New Mexico, northwestward. Has 193 miles of 4 to 24-in. line in Mocane and Laverne, Oklahoma, fields for *Colorado Interstate Gas Company*. For *Laurel Pipe Line Company*, 78 miles of 20-in. from Mechanicsburg, Pennsylvania, to Duncansville, 118 miles of 18-in. from the latter point to Aliquippa station, Pennsylvania.

● **Mid-States Construction Company, P. O. Box 417, Mt. Vernon, Illinois.** Has contract for 50 miles of ¾ to 2-in. and 4 to 6-in. distribution and service lines in Desota, Missouri (Project 5), for *Missouri Natural Gas Company*. This work is to start March 1.

● **Mannix Company, Ltd., 332 Seventh Avenue West, Calgary, Alberta.** Has 93 miles of 30-in. for *Northern Ontario Pipe Line Crown Corporation* from a point 30 miles west of Hearst running to Kapus Kassing, Ontario. Right of way clearing is being completed and pipe laying is to begin between May 15 and June 1. Has 30 miles of 3-6-in. gathering system in Drayton Valley, Alberta area for *Pembina Pipeline Company*. This is a continuing contract with Pembina, of which 500 miles have now been completed since 1954.

● **Lone Star Pipe Line Constructors, Inc., 10301 Shady Trail, Dallas, Texas.** Has 143 miles of 20-in. crude line between Teague and Houston, Texas, for *Sinclair Pipe Line Company*. Also has 30 miles of 16, 14, 10 and 4-in. for *Transcontinental Gas Pipe Line Company* from a point near Tilden, Texas, westward.

● **Golightly Construction Corporation, Box 15243, 6450 Liberty Road, Houston 20, Texas.** Has 6 miles of 20-in. line on the Houston end of *Sinclair Pipe Line Company's* North Texas to Houston crude line.

● **Hunsaker Trucking Contractor, Inc., 11476 Harry Hines Blvd., Dallas, Texas.** Has stringing contract for 20 miles of 16-in. between Electra and Wichita Falls, Texas, and 25 miles of 12-in. between Bellevue and Wichita Falls, both for *Lone Star Gas Company*. Has 30 miles of 12-in. to string between Sonora and Eldorado, Texas, for *Pioneer Natural Gas Company*.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has contract for the 70.9 miles, 30-in. Spread X of *Northern Ontario Pipeline* between Beardmore to Longlac, Ontario. Has undetermined amount of gathering system for *Producers Pipeline Ltd.* in the Estavan, Saskatchewan, area. Has contract to lay city distribution system in Cooksville, Ontario, for *Consumer Gas Company*. Has city distribution system in Guelph, Ontario, for *Union Gas of Canada*. Has contract for testing *Trans-Canada Pipeline's* line from Alberta to Winnipeg, Manitoba.

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston, Texas.** Has undetermined amount of various size pipe to lay for *Pacific Northwest Pipeline Company* for gathering system in Four Corners area. Also has undetermined amount of gathering system line for *El Paso Natural Gas Company* in the Four Corners area. Has gathering system to lay for *Pacific Northwest Pipeline Company* in the Big Piney field, Wyoming; amount and size of pipe is undetermined.

● **Vaughn and Taylor Construction Company, Inc., P. O. Box 3266, Odessa, Texas.** Has contract for 48 miles of 8, 6, and 4-in. line between Kermit and Goldsmith, Texas, for *El Paso Natural Gas Company*.

● **Missouri Valley Dredging Company,** 1331 South 20th Street, Omaha, Nebraska. Has 5.6 miles of 24-in. for *Laurel Pipe Line Company* from Eagle Point, New York, to west bank of Delaware River including the river crossing. Also 20 miles of 24-in. from that point to Booth station site in Delaware County, Pennsylvania.

● **Engineers Limited Pipeline Company,** 225 Bush Street, San Francisco. Has 106 miles of 24-in. for *Laurel Pipe Line Company* from Booth station, Delaware County, Pennsylvania, to Mechanicsburg.

News

Atlantic Seaboard Gas Lines Receive OK

The Federal Power Commission has granted Atlantic Seaboard Corporation authorization to construct and operate natural gas facilities, at an estimated cost of about $2,459,800, in West Virginia and Virginia.

Atlantic will construct about 5.7 miles of 26-in. transmission line loops in Hardy and Grant counties, West Virginia; install an additional 2000 hp unit at its Cleveland compressor station in Upshur County, West Virginia; install an additional 2000 hp unit at its Files Creek station in Randolph County; install an additional 880 hp unit at its Huff Creek compressor station in Wyoming County, West Virginia, and construct and operate an additional measuring and regulating station in Albemarle County, Virginia, for additional wholesale deliveries to Virginia Gas Distribution Corporation.

Northern Natural to Build in Panhandle

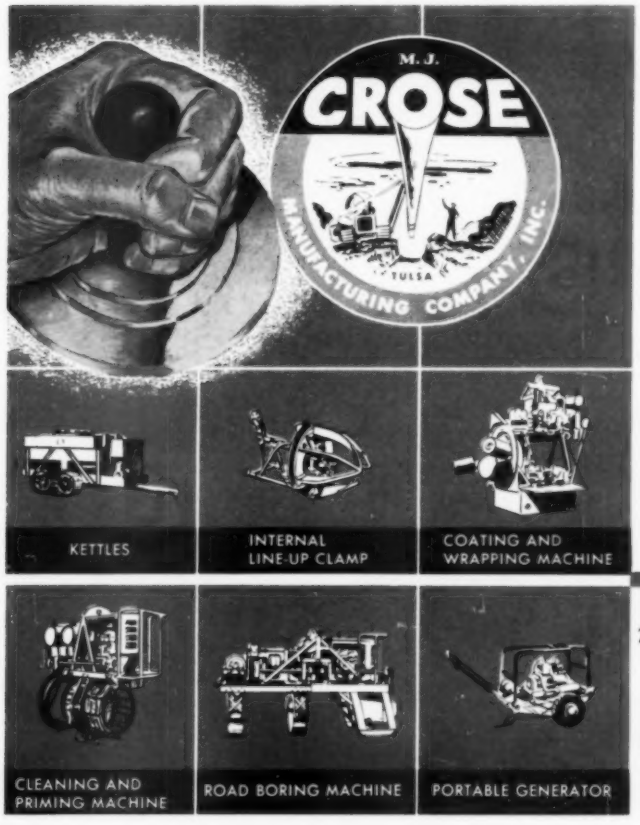
The Federal Power Commission has granted Northern Natural Gas Company authorization to construct 27.6 miles of 30-in. natural gas loop pipeline at an estimated cost of approximately $3,020,000.

Northern proposes to construct about 18.3 miles of line north of its Beaver compressor station in the Oklahoma Panhandle and 9.3 miles of line north of its Sunray station in the Texas Panhandle.

United to Lay More Lines in Southern Louisiana

The Federal Power Commission has authorized United Gas Pipe Line Company to construct and operate natural gas pipeline facilities in Terrebonne Parish, Louisiana, at an estimated cost of approximately $2,653,210.

United will construct about 13 miles of 16-in. transmission pipeline, with appurtenant facilities, to extend from the end of its existing 20-in. Kent Bayou field lateral line to a point in the Halter Island field area. United was also authorized to construct about 17.4 miles of 8-in. lateral supply lines, meter stations, and such other facilities as may be needed from time to time to take additional deliveries from wells in the area.



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Completing Gas Gathering System in West Texas

Sinclair Oil & Gas Company and Skelly Oil Company are completing an extensive field gas gathering system connecting six fields in Schleicher and Tom Green counties, Texas, to their jointly-owned Gas Products Plant No. 23 in the Hulldale field of Schleicher county.

In addition, preliminary work is underway to gather gas from three additional fields in Schleicher County.

With Sinclair as operator, the plant began operations in July 1956, processing oil-well gas gathered from the Hulldale, North Hulldale and Cox Brown fields.

Through installation of an additional 1100-hp compressor at the main plant and the installation of the extensive gathering system, oil-well gas is being gathered from the Mount Susan and Pecan Station field in Tom Green County and from the O'Harrow, Butler, Toenail Trail, and Otto fields in Schleicher County.

A 200-hp compressor has been installed in each of the Pecan Station and Mount Susan fields.

Pioneer Gathering System, Inc., is under contract to take the full volume of residue gas from the plant. Prior to delivery to Pioneer, residue gas is dehydrated and desulfurized.

Franklin Parker Named to Petrol-Structors Post

Petrol-Structors, Ltd., consulting engineers, Calgary, Alberta, announces the appointment of R. Franklin Parker as executive vice president, general manager, and director. Petrol-Structors has been engaged in project management, design, inspection, and construction supervision in western Canada and Alaska since 1952 having handled such projects as the Pembina Pipeline.

Parker is well known in the Southwest and West, having been associated with O. L. Olsen Company in Houston for a number of years and most recently with Bechtel Corporation in San Francisco.

Under Parker's management Petrol-Structors will continue work in the pipeline industry and will extend operations into gas and oil processing, petro-chemical, and industrial plants.

Service to Consolidate Two Operating Divisions

Consolidation of two major operating areas covering trunk line and gathering systems in Wyoming, Colorado, Kansas, and Utah is announced by Service Pipe Line Company.

H. G. Mariner, general manager, said the recently acquired crude oil lines of the Utah Oil Refining Company, which have been operating as the company's Utah division, will be consolidated March 1 with the present Wyoming division. R. R. Strand of Casper, manager of the Wyoming division, will assume supervision of about 1000 miles of lines in the Utah system.

The two districts in northwestern Colorado and southwestern Wyoming to be added to Strand's divsion, have headquarters at Craig, Colorado, and Rawlins, Wyoming. J. W. Cox will remain as district superintendent at Craig and L. F. "Roy" Dorrell will continue as district superintendent at Rawlins.

A segment of the Wyoming division known as the Sterling district in Colorado will be added to the Kansas division. This district, with headquarters at Sterling, Colorado, will be placed under the supervision of C. A. Childers, Wichita, manager of the Kansas division. District Superintendent Opal Blair will remain in charge of the Sterling district.

H. M. Hill, present manager of the Utah division, will succeed Childers as manager of the Kansas division on Childers' retirement next May 10.

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Oil and gas pipelines need extra protection from rock abrasion and penetration in areas such as mountain cuts and river crossings. Ruberoid *Flexible* Pipeline Shield is the made-to-order extra protection to insure long, maintenance-free pipeline performance.

Ruberoid Pipeline Shield is made of premium felt, saturated with Bitumen and lined on one side with a tough kraft crepe paper to provide more flexibility. This rugged, durable covering will withstand extremes of abrasion and penetration and keep lines in service without costly repair interruptions.

Ruberoid Pipeline Shield is easy to apply right over the standard felt and enamel outer covering. It is available in 8' to 10'2" lengths . . . in widths from 17" to 60" to fit any size pipe. One or two man crews can install it quickly with 1" metal strapping. Seals (600 per 1000') are just as simple to install.

When laying pipelines in extra tough areas, add an extra margin of safety with Ruberoid Pipeline Shield. It will provide extra years of trouble-free service.

The RUBEROID Co.

Executive Offices: 500 Fifth Avenue, New York 36, N. Y
Western Division Offices: 307 N. Michigan Ave., Chicago 1, Ill.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

NEW EQUIPMENT

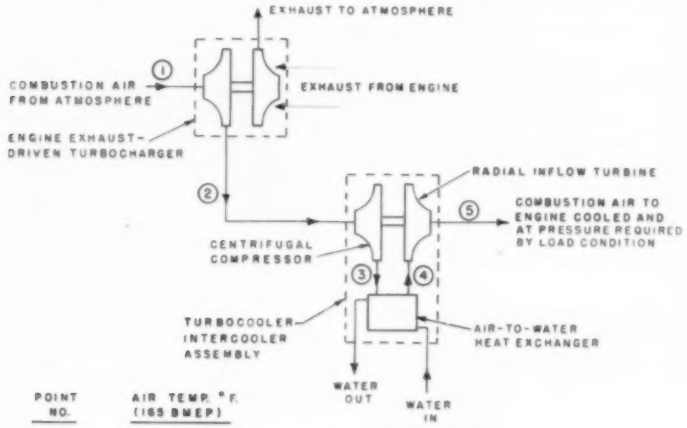
Pulling More Engine Horsepower With Less Fuel

Turbocooling, a method for supercooling combustion air, provides an important potential for increasing horsepower output of gas or gas-diesel engines. In some cases these increases are as much as 23 percent. At the same time, reductions as high as 5 percent in fuel consumption are being realized, according to actual field experience.

Basically, the Cooper-Bessemer turbocooler is a turbine-driven centrifugal compressor equipped with an aftercooler. The turbocooler utilizes an abundant source of energy created by a pressure drop in the manifold, which would further cool the combustion air going to the engine cylinders. Filtered air enters the high pressure turbocharger (1) and is compressed by the exhaust gas driven centrifugal blower (2). Pressurized air at elevated temperature from compression is then directed to a booster (3) in the turbocooler for a second stage of compression.

As the air leaves the booster its temperature and pressure are considerably higher than after the first stage of compression. This air is then cooled by an air-to-water intercooler (4) before entering a turbo-expander (5). Since the pressure of the air entering the turbo-expander (5) is greater than the air intake requirements of the engine, a pressure drop is available through the expander to motivate the expander impeller causing the impeller to spin. As the same air expands through the impeller, its temperature is reduced by 15 to 40 deg.—*The Cooper-Bessemer Corporation.*

Circle number (81) on reply card.



POINT NO.	AIR TEMP. °F. (165 BMEP)
1	90
2	195
3	230
4	100
5	60

Cooling cycle of Cooper-Bessemer turbocooler.

Automotive Generator

Of special interest to operators of vehicles plagued by chronic battery trouble due to lack of charging current, is a new low cut-in generator announced by American Bosch. The generator, designated as the SSG and its companion regulator the SSR, are both heavy-duty units designed to withstand the rigors of severe service in commercial vehicles such as trucks.—*American Bosch Division, American Bosch Arma Corporation.*

Circle number (82) on reply card.

Crane Tamper Attachment

Schield Bantam Company announces a specially designed tamper attachment for its line of power cranes-excavators. The addition of the tamper attachment makes a total of 10 specially designed attachments now available on either the crane carrier-mounted, crawler-mounted, or self-propelled model Bantams. A feature of the tamper is that it offers 80-100 percent compaction at a maximum penetration of 3 ft.—*Schield Bantam Company.*

Circle number (83) on reply card.

Wind-Driven Generator

A wind-driven power package consisting of a 6-kw wind generator, battery bank, and a standby Nordberg Power Chief diesel generator is being manufactured to provide electrical power in remote, isolated areas. It is designed to operate on a fully automatic basis, thus reducing maintenance to one-fourth of that required for the usual diesel plant.—*Automatic Power, Inc.*

Circle number (84) on reply card.

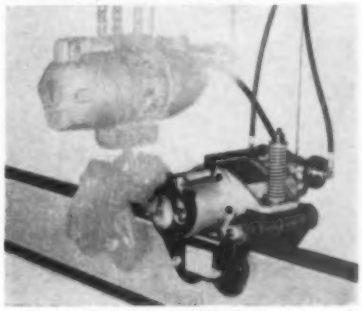
New Valve Design

Kerotest Manufacturing Company has put into production a new concept in valve design. This is the new Keroseal, a non-lubricated, optional-flow, double block, and bleed full opening valve. The valve is designed to handle gases, petroleum products, petrochemicals, fluids, and numerous other products. — *Kerotest Manufacturing Company.*

Circle number (85) on reply card.

Powered Hoist Trolley

Now, one man can raise, lower or move loads up to 2 tons with positive control. It's all done with a new powered hoist trolley, the "Hoistractor," announced by Gardner-Denver.

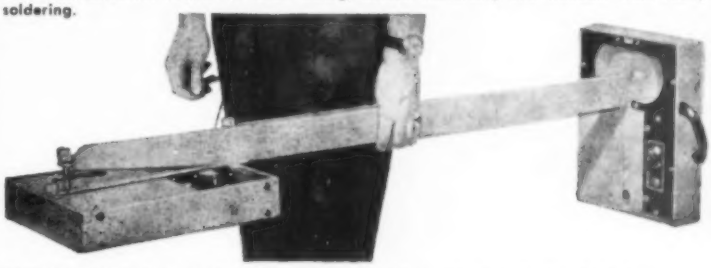


Powered by an axial-piston type air motor, the "Hoistractor" exerts 250-lb drawbar pull on a beam through a rugged spring-loaded Neoprene drive wheel. It will pull a 2-ton load at 70 ft per min. Speed can be varied from a slow creep to full speed of 150 ft per min.—*Gardner-Denver Company.*

Circle number (86) on reply card.

The WILKINSON LINE LOCATOR
PREVENTS COSTLY DAMAGE

Spots all sub surface pipes, cables, etc., and determines their depth accurately.
ETCHED CIRCUITRY: instead of hand wiring, insures uniformity and freedom from faulty soldering.



BATTERY TESTER: instantly indicates battery condition without removing batteries.
INSTRUMENT CASE: Made of tough, wear resisting phenolic material. The antennas are an integral part of cases, moisture and shock proof.

WILKINSON PRODUCTS COMPANY
3987 Chevy Chase Drive, PASADENA 3, CALIFORNIA. SYlvan 0-4314

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

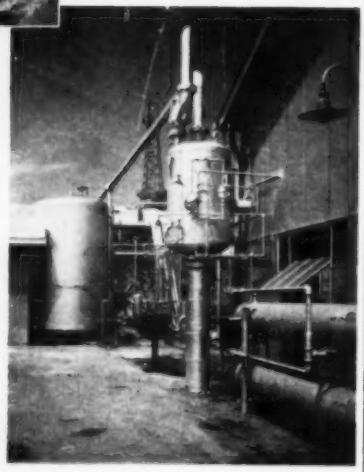
VAPOR PHASE® LENGTHENS ENGINE OVERHAUL LIFE

From 8,500 Hrs. to 25,000 Hrs. For Tidewater Oil Company

At the Hartman Lease Gas Compressor Station of the Tidewater Oil Co., Ventura, Calif., seven engine-compressor units are in operation: 1-150 bhp unit and 6-300 bhp units. The Vapor Phase installation includes a patented single Steam Separator, condensate unit, crude oil heater and steam turbine driven fan condensers.

Before Vapor Phasing, complete engine overhauls were required after 8,500 hours. Now the overhaul period has been extended to over 25,000 hours! Ring sticking is practically nil and carbon deposits are negligible.

The 5850 lbs. steam/hr. produced by the engines is now used to heat crude oil to help separate water and sludge from oil, and to heat workmen's change room. A Vapor Phase crude oil heater has replaced gas-fired oil treaters. The cooling tower used to cool engines has also been completely eliminated.



Thermal Circulation in all engines is accomplished by one large Vapor Phase unit, thus eliminating water pumps.

WRITE for full story on Vapor Phase economy — for your installation.

"Sole Developers and Manufacturers of Vapor Phase® Thermal Circulation (Ebullition) Engine Cooling Systems."

E C VAPOR PHASE

ENGINEERING CONTROLS Inc.

An Affiliate of St. Louis Shipbuilding & Steel Co.

611 E. Marceau St. St. Louis 11, Mo.

1939 N. Hillhurst Ave. Los Angeles 27, Calif.

New Equipment

Two-Way Radio Slide Rule

A pocket-size "Service Datalizer" slide-rule condensing information normally found in more than 50 instruction books has been devised by General Electric's communication products department for servicemen maintaining 2-way radio systems. The Datalizer provides information on correct tuning, meter types, meter readings which normally occur in the transmitter and receiver during tuning, power supply information, and other data on 2-way equipment manufactured by G-E in the past decade.—*General Electric Company.*

Circle number (87) on reply card.

Pipeline Insulator

A rugged new plastic insulator, said to be impervious to moisture, corrosion and decay, has been developed by the F. H. Maloney Company. Designed to absorb load shocks and provide cathodic protection at pipeline crossings, the Model 57 insulator is available in size ranges from 2 through 36 in. Composed of glass fiber reinforced polyester, it is compression molded at controlled high temperature and high pressure.

It is ribbed inside to prevent cold flow of the pipe wrap and has been extensively field tested, laboratory tested in excess of 18 tons and temperature tested in excess of 400 F in boiling hot-pipe-coat (pitch). —*F. H. Maloney Company.*

Circle number (88) on reply card.

Handgun Simplifies Valve Lubrication

A new high-pressure hydraulic handgun specially designed for plug valve lubrication is offered by Rockwell Manufacturing Company. The new Rockwell 400-C is self-priming and can be used in any position. Because of the extra-high pressure this gun exerts, the hose and coupler can be locked to the buttonhead fitting in the valve shank. The pressure may be relieved by a turn of the by-pass valve on the gun, readily permitting separation of the buttonhead coupler and fitting.—*Rockwell Manufacturing Company.*

Circle number (89) on reply card.

Locates Engine Trouble

Secondary signal information, the unknown in system analysis on low speed industrial engines, can now be viewed with Du Mont's new Industrial EnginScope. The instrument is the only oscilloscope engine analyzer for spark ignited industrial equipment to feature a multi-line presentation, cylinder-by-cylinder, it is stated. *Allen B. Du Mont Laboratories, Inc.*

Circle number (90) on reply card.

Wrap Zips Over Pipelines

A new method for protecting pipelines has been developed by the Zippertubing Company. A flat vinyl backed, uncured butyl rubber tape is utilized that is simply wrapped around the pipeline, then zipped shut by means of a plastic track.

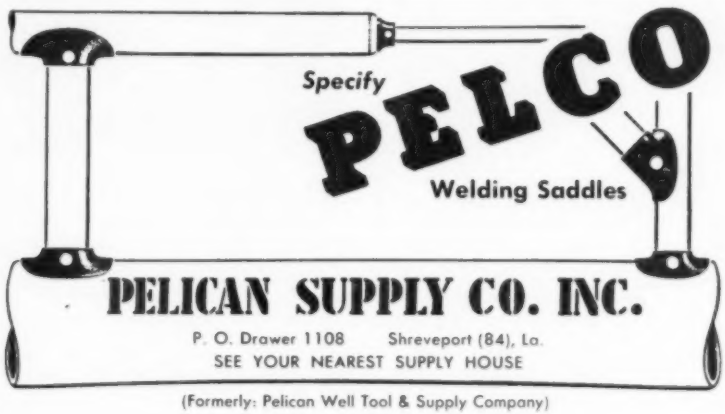
Available in widths wide enough to surround the largest pipe, this Zippwrap provides protection against corrosion, abrasion, fungus, and many other elements damaging to pipelines, the manufacturer states. — *The Zippertubing Company.*

Circle number (91) on reply card.

Full Circle Brake

A heavy duty, full circle brake for off-the-road equipment has been announced by B. F. Goodrich Aviation Products. Named the "Hi-Torque," it is the first hydraulic drum type brake with 360-deg expander tube actuation designed for large tractors, scrapers, and earthmovers. The new brake operates with nearly constant lining pressures at all points around the drum area, at only one-half the usual maximum lining pressure encountered with anchored shoe brakes. *B. F. Goodrich Aviation Products.*

Circle number (92) on reply card.



PELICAN SUPPLY CO. INC.

P. O. Drawer 1108 Shreveport (84), La.
SEE YOUR NEAREST SUPPLY HOUSE

(Formerly: Pelican Well Tool & Supply Company)

MOLE
Pipeline
Cleaner

for BETTER cleaning of
CRUDE LINES
PRODUCT LINES
NATURAL GAS LINES

FOR DETAILS WRITE

Pipeline Cleaners Co.
Fort Madison, Iowa

Spy Detector

. . . our SPY HOLIDAY DETECTORS are as near as your telephone—in fact, in emergencies our own plane assures immediate service.

Rugged equipment for dependable holiday detection on ¼" to 36" pipe . . . signal—bell, light and spark . . . unaffected by dew or frost.

Call, wire or write.

Pipeline Inspection Co., Inc.
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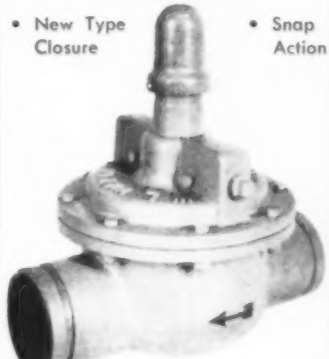
Day Phone:
BAltimore 1-6036
Night Phone:
HI 4-6745, EM 1-3824

Got Problems with AIR?

• New Type Closure • Snap Action



• Balanced Piston with O-Ring Seal
• Grooved Ends • Easy Installation

Get New WALKER AUTOMATIC SHUT-OFF VALVE

For additional information write

W. L. Walker Co.
Phone: Diamond 3-8241
1009 South Main Tulsa, Oklahoma

New Equipment

Construction Trailer

A new type trailer for pipeline construction and maintenance is announced

by Stahl Metal Products, Inc. Compartments are designed for carrying tools and materials to and from the job. Doors are equipped with flush door handles and locks keyed alike. The trailer is theft-proof. Trailer is equipped with an adjustable landing gear that makes it very easy to attach the trailer towing ring to a passenger car or truck for towing.

Adjustable rear jack serves to stabilize the trailer when parked on the job spot. Interior space of trailer provides a cushioned seat arrangement for the seating of three men. — *Stahl Metal Products, Inc.*

Circle number (93) on reply card.

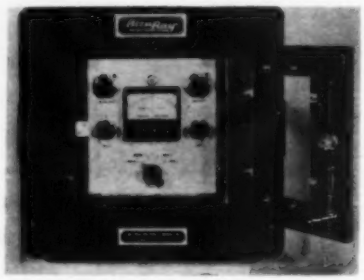
Tractor Normalizing Kit

The D6 tractor joins the D7 and D8 to become the third machine in the company's line to be provided with a normalizing kit. The new kit, which consists of a turbocharger and all manifolds needed to mount it on the tractor engine, overcomes the cause of high altitude power loss — insufficient oxygen to permit complete combustion of fuel. — *Caterpillar Tractor Company.*

Circle number (94) on reply card.

Density Measurement System

An AccuRay density system that measures and/or controls fluid density, specific gravity, percent solids, or related quantity has been announced by Industrial Nucleonics Corporation. Based on the principles of gamma ray transmission from a radioisotope, the system makes no physical contact with the flowing material. Measurements are also independent of flow rate and pressure.



Depending upon the process and material measured, long term accuracies of ± .001 to ± .003 specific gravity are readily obtainable. The system can be furnished with sensitivities to the order of 0.0001 specific gravity. Built-in standardizing circuits maintain accuracy and calibration, and any component, except radiation source or detector, can be replaced without affecting calibration.— *Industrial Nucleonics Corporation.*

Circle number (95) on reply card.

Point-to-Point Two-Way Radio

Increasing use of station-to-station communications facilities to supplement mobile radio systems has become increasingly important. Particularly significant has been a growing need for radio circuits to remotely control isolated base station and radio relay equipment, extending range of a mobile radio system, or overcoming certain types of interference.

Motorola has made available equipment to operate in the 890 to 960-mc UHF range, providing point-to-point radio circuits for remote control and other purposes. Although some lower frequency channels are available to certain services for this use, growing channel occupancy by mobile units is expected to require most point-to-point circuits to operate above 890 mc with equipment of this type.—*Motorola, Inc.*

Circle number (96) on reply card.

Experience

There is no Substitute for Proven Experience

Houston
CONTRACTING COMPANY
GENERAL CONTRACTORS
Laurence H. Favrot • R. P. Gregory • Geo. A. Peterkin

OIL • GAS
GASOLINE
WATER PIPE LINES

2807 Buffalo Speedway

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

NEW LITERATURE

Squirrel Cage Induction Motors

New, condensed, 2-page product sheets are now available describing the Electric Machinery Manufacturing's line of squirrel cage induction motors. Both horizontal and vertical types are illustrated. The sheets are 3-hole punched to easily fit in the 3-ring binder. Described in detail are the types of construction including bearings, enclosures, and exclusive details on the E-M squirrel cage. Ratings of the motors are from 60 through 4000 hp. Speeds vary between 450 rpm through 1800 rpm. The motors are of heavy-duty construction throughout. — *Electric Machinery Manufacturing Company.*

Circle number (97) on reply card.

Close-Coupled Pumps

The verti-line close-coupled pumps of Layne & Bowler Pump Company are engineered for booster service, fire protection, cooling, transfer, and general service pumping of water and other fluids, corrosive or non-corrosive, hot or volatile. New brochure indicates capacities are from 20 gpm to 30,000 gpm; heads to 600 psi.—*Layne & Bowler Pump Company.*

Circle number (98) on reply card.

Higher Ratings for Blowers, Gas Pumps

Increased capacity ratings have been announced by Roots-Connersville Blower for the full line of type AF rotary positive blowers and type XA rotary positive gas pumps. These ratings have been made possible by design refinements permitting higher operating speeds which result in greater efficiency. Complete rating tables, specifications and design data are presented in detail in available bulletin.—*Roots-Connersville Blower, Division of Dresser Industries, Inc.*

Circle number (99) on reply card.

Bridge Construction

A new bulletin on pipeline bridge construction has been released by Pittsburgh-Des Moines Steel Company. The publication attractively pictures a number of the many modern bridges built for pipeline crossings by PDM, including suspension, truss, trestle, and cantilever types.—*Pittsburgh-Des Moines Steel Company.*

Circle number (100) on reply card.

Large Induction Motors

The Louis Allis Company has published a new 16-page bulletin on large induction motors, presenting detailed information on a full line of motors in ratings from 150 to 1250 hp. Cutaway drawings and illustrations show the protection offered by the open drip-proof, splash-proof, enclosed and explosion-proof enclosures in which these motors are built.—*The Louis Allis Company.*

Circle number (101) on reply card.

History of Koehring

"This is Koehring" is a 40-page brochure released by Koehring, presenting a history of the company and its divisions and subsidiaries.—*Koehring Company*

Circle number (102) on reply card.

A Specialty of the House —

"BRANDED PROTECTION"

for pipe lines!

For over a dozen years, Midwestern has led the field in protecting pipe from corrosion and abuse, whether above or below ground. Our field-trained technicians specify only the highest quality "top-brand" materials to assure faster and easier application, longer life, tougher reinforced coatings . . .

Regardless of job conditions, *one or a combination* of these excellent products will furnish the "branded protection" you need — "GLASFAB" and GLASKOTE handwraps . . . MALONEY crossing insulators and casing seals . . . COROMAT underground wrap . . . KERMAC outerwrap . . . KEYSTONE asbestos felt . . . KAPCO rock shield . . . PITT CHEM tar base coatings.

There's a Midwestern specialist near you . . . ready to serve you quickly, expertly, economically.

MIDWESTERN
PIPE LINE PRODUCTS CO.
4645 Southwest Blvd. Tulsa, Okla. HI 6-6144
Cable Address: Mid Pipe

branch offices—
- Houston, Tex.
- Atlanta, Ga.
- Mt. Prospect, Ill.
- Pittsburgh, Pa.
- Oklahoma City, Okla.
- New York, N.Y. (export)
- Caracas, Venezuela

After the right-of-way of the line through northwestern Ontario was cleared of rock out-croppings, specially rigged shot-hole machines made the preparations for blasting the ditch itself.

DELIVERY OF ALBERTA GAS TO LAKEHEAD CITIES A REALITY

Delivery of Alberta natural gas to the Lakehead cities of Fort William and Port Arthur is now a reality.

Charles S. Coates, president of Trans-Canada Pipe Lines, Ltd., and R. K. Farris, president of Northern Ontario Natural Gas Company and executive vice president of Twin City Gas Company, Ltd., distribution companies in the northwestern Ontario area, term this a major milestone in the $378,000,000 drive to span most of Canada with a great new economic artery — the Trans-Canada Pipe Line. With the completion of the line from the Alberta-Saskatchewan border to the Lakehead and from Toronto to Montreal and Ottawa in 1957, more than 60 percent of the Trans-Canada project has been completed.

Building of the 30-in. section of the all-Canadian pipeline to the Lakehead was completed on schedule during the 1957 construction program. The section from the Manitoba-Ontario border to the Lakehead, together with the link from Port Arthur to Kapuskasing, is being built by the Northern Ontario Pipe Line Crown Corporation, with design and supervision of construction under Trans-Canada Pipe Lines, which will rent this section with an option to purchase it.

Alberta natural gas is now being delivered by Trans-Canada to the Saskatchewan Power Corporation, at Regina and Valjean, Saskatchewan, to Winnipeg, Brandon, Rivers, Portage La Prairie, Neepawa, Hamiota, and Steinbach in Manitoba; Kenora and the Lakehead, Ontario.

In the east a temporary supply of natural gas is being delivered through the Trans-Canada line to Montreal, Ottawa, Bowmanville, Lindsay, Brockville, and to Toronto through the Niagara-Toronto section, which is under lease to Consumer's Gas.

1958 Work Started

Work on the 853 miles of the 1958 construction program already has started. Materials are being stock-piled along the route, right-of-way is being cleared and preparations are underway for an early start on actual pipe laying. The 1958 program includes 367 miles of 30-in. pipe on the Crown section from Port Arthur to Kapuskasing and 486 miles of 30-in. line on the Trans-Canada portion from Kapuskasing to Toronto. Five construction contracts have been let on the Crown section and seven on the Trans-Canada section.

Completion of the line, which will signal the use of Alberta gas in the homes and industries as far east as Montreal, is scheduled for the fall of 1958.

Work by Northern Ontario Natural Gas and Twin City Gas on their distribution systems in Kenora, Dryden, Fort William and Port Arthur is on schedule. Twin City has installed more than 41 miles of an eventual 300 miles of distribution lines. The work will be completed as soon as the frost is out of the ground this spring. Ultimately the two distribution firms will serve 34 communities between the Manitoba border and Orillia, Ontario.

During the 1957 construction season Trans-Canada and Northern Ontario Pipe Line Crown completed almost 1400 miles of pipeline work. This included the final portion of the western section, 584 miles of 34-in. diam pipe from the Alberta-Saskatchewan border to the Winnipeg area; 85 miles of 30-in. pipe from the Winnipeg area to the Manitoba-Ontario border; 315 miles of 30-in. pipe on the Crown section from the Manitoba-Ontario border to the Lakehead; 310 miles of 20-in. line from Toronto to Montreal; 33 miles of 16-in. line from Morrisburg to Ottawa, and 33 miles of 24-in. line from Toronto to Sheridan.

The roughest construction conditions in 1957 were encountered on the Crown section from the Manitoba border to Port Arthur. For almost all of the 315 miles the pipeliners had to battle their way through solid granite, long treacherous stretches of muskeg, and around or under any number of lakes and streams. ★ ★ ★

RIG LOCATOR

SPRING 1958

An exclusive Directory of oil field contract drilling rigs — rotary and cable tools — in The United States and Canada — including a special off-shore section — and some foreign operations.

the Petroleum Engineer

BOX 1589 • DALLAS 21, TEXAS

Strong Joints for Long Strings

J&L BUTTRESS-THREAD CASING

J&L Buttress-Thread Casing joint is designed to support great weight.

The long coupling has completely engaged runout threads (five per inch) with ¾" taper per foot and a flank angle of three degrees. The Buttress-Thread, applied to non-upset casing, develops practically the full strength of the body of the pipe.

J&L Buttress-Thread stabs easily and makes up quickly — a time saver.

The product, as in the case of all J&L pipe, is of high quality by reason of mine-through-mill methods and controls of exceptional precision and care.

Available in seamless casing in grades J-55, N-80, P-110 and higher grades.

For further information consult your near-by J&L Supply store, sales office, or resident salesman.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

J&L – A GREAT NAME IN STEEL

(44)

The Petroleum Engineer's SPRING 1958

DRILLING RIG LOCATOR

Now in its third year, this eighth edition lists over 2800 rigs owned and operated by nearly 800 drilling contractors in the U. S. and Canada. Also included is a special section on U. S. offshore operations along with a list of some foreign contract rigs.

Here's what it contains:

- **Contractors name and address**
- **Rig number or name**
- **Type power and fuel**
- **Total hp to main mud pumps**
- **Drawworks make and model**
- **Hp available to drawworks**
- **Rated drilling depth**
- **Current location**

This is the eighth exclusive directory of contract drilling rigs, listing the names and addresses of drilling contractors in the U. S. and Canada, pertinent specifications of both rotary and cable tool rigs, as well as their location. This is the third year of publication of the RIG LOCATOR which had its pioneering beginning in October 1955.

Its primary purpose is to provide sufficient information about each contract rig for evaluation purposes when an operator needs a certain type and size of rig to drill a well in a specific area. The number of drilling contractors and rigs listed has continued to grow, reaching an all-time peak in October 1957 of 850 contractors and well over 3000 rigs.

This directory is offered the industry at no expense to contractors participating. Both rotary and cable tool rigs are listed separately in the U. S. and Canada. And, a special section was added last year to include not only contract drilling rigs in the offshore areas of the Gulf of Mexico and California but also includes operator-owned offshore units. Also included are some contract drilling rigs in foreign service.

Use of abbreviations. In a directory of this type where certain specifications are included, it was necessary in the conservation of space to make some abbreviations. Under the column of "type power," the following abbreviations apply: Dsl for diesel; gaso for gasoline; stm for steam; btne for butane; and dsl elec for diesel electric. In listing drawworks make and model number, it was necessary to abbreviate the manufacturer's name. Some of these abbreviations are well known; others had to be made to fit the available space. Here's the code we used:

Manufacturer's Company Name	Abbreviation
ALCO Products, Inc. (formerly Beaumont Iron Works Div. of American Locomotive Co.)	ALCO-BIW
Allis-Chalmers Manufacturing Co.	Allis Chmrs
American Iron & Machine Works	Amer
Ansaldo	Ansaldo
Beaumont Iron Works (See ALCO Products, Inc., name no longer officially used)	ALCO-BIW
Bethlehem Supply Co.	Beth
Big Four Machine & Supply Co.	Big Four
The Brewster Co., Inc.	Brwstr
Bucyrus-Erie Co.	B. Erie
Cardwell Manufacturing Co., Inc.	Crdwll
Clark Bros. Co., Inc.	Clark
Fred E. Cooper, Inc.	Cooper
Continental-Emsco Co.	Emsco
Cummins Engine Co., Inc.	Cummins
George E. Failing Co.	Failing
Franks Division of Cabot Shops, Inc.	Frnks
General Machine Co.	Gen Mach
Hacker Machine & Supply Co.	Hacker
Hopper Machine Works, Inc.	Hopper
Houston Tool Co.	Hou
Howard-Turner Machine Works	Howard-Turner
Ideco, Inc.	Ideco
Ingersoll-Rand Co.	Ingersoll
Jones, Shelburne & Guffey Co.	JS&G
Joy Manufacturing Co.	Joy
Mayhew Supply Co., Inc.	Mayhew
Lee C. Moore Corp.	L. C. Moore
Lucey Export Corp.	Lucey
Muskogee Iron Works	MIW
The National Supply Co.	Natl
Oil Well Supply Division (U. S. Steel Corp.)	"Oilwell"
Reich Bros.	Reich
Spencer-Harris Machine & Tool Co.	Spencer
Stardrill-Keystone Co.	Star
Texas Iron Works, Inc.	TIW
Unit Rig & Equipment Co.	Unit
Wagner-Morehouse, Inc.	Wgnr-Mrhse
Walker-Neer Manufacturing Co., Inc.	Wlkr-Nr
Waldrip Engineering Co.	Wldrp
Well Machinery & Supply Co., Inc.	Ft. Wrth
Wheeling Machine Products Co.	Wheeling
The Wheland Co.	Whlnd
Wichita Tool Supply Co.	Wich
Wichtex Machinery Co., Inc.	Wichtex
Wilson Manufacturing Co., Inc.	Wlsn

U. S. Drilling Contractors

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

A

A & P Drlg Co Inc Box 568 Duncan Okla
Abb Drlg Co 300 Oil & Gas Bldg Wichita Falls Tex
Acacia Drlg Co Box 881 Tulsa Okla
Ace Drlg Co 1800 Republic Natl Bk Bldg Dallas Tex
Admiral Drlg Co Inc 2930 Pease St Houston 3 Tex
Akin & Dimock 714 Holliday St Wichita Falls Tex
Alan Drlg Co 807 Oil & Gas Bldg Wichita Falls Tex
Aldridge and Stroud Inc Box 962 Odessa Tex
Allen & Morris 820 Alamo Natl Bldg San Antonio Tex
Allen Drlg Co 4410 Venable Ave Charleston 4 W Va
W C Allen Box 263 Oil City La
B F Allison Drlg Co 626 Patterson Bldg Denver Colo
Anderson Drlg Co 730 Wichita Natl Bk Bldg Wichita Falls Tex
Anschutz Oil Co Inc Box 1466 Casper*Wyo
An-Son Drlg Co 3814 N Santa Fe Oklahoma City 18 Okla
Appell Petroleum Corp Box 330 Alice Tex
Arapahoe Drlg Co 1020 Petroleum Club Bldg Denver Colo
Armstrong & Horn Drlg Co 640 Milam Bldg San Antonio 5 Tex
Arrow Drlg Co 407 Philtower Bldg Tulsa Okla
Austin Drlg Co Box 1240 Seminole Okla
Austin-Dunham Inc Box 1240 Seminole Okla

B

B & G Well Maintenance Box 6825 Houston Tex
B B M Drlg Co 673 San Jacinto Bldg Houston 2 Tex
B J & M Co Ltd 160 S Fairfax Ave Los Angeles Calif
B-M Drlg Co Inc Box 5218 Bossier City La
Badger Drillers Inc Box 287 Tulsa Okla
Pernie Bailey 2309 Sage Rd Houston Tex
Baker & Taylor Drlg Co 712 First Natl Bk Bldg Amarillo Tex
Darris Ballew Inc Box 561 Natchez Miss
Bar-Lee Drlg Co Box 7264 Tulsa Okla
Barnes Core Drlg Co 1350 Roberts Ln Bakersfield Calif
Barnwell Drlg Co Inc Box 1748 Shreveport La
Barnwell Offshore Inc Box 1748 Shreveport La
Barrett Petroleum Co 423 Masonic Bldg Shawnee Okla
Basin Drlg Corp Box 1388 Duncan Okla
Bass Drlg Co 905 San Jacinto Bldg Houston 2 Tex
Harry Bass Drlg Co 1403 Magnolia Bldg Dallas Tex
Robert M Bass Drlg Contr Box 471 Kilgore Tex
Bateman Drlg Co 420 Saratoga Bldg New Orleans La
Bay City Drlg Co Inc Box 1389 Bay City Tex
Beardmore Drlg Co 827 Beacon Bldg Wichita Kans
Beckman Inc Box 1524 Muskogee Okla
Dudley C Beene Inc Suite 1117 Town House Shreveport La
Bennett & Roberts Drlg Co Drawer 633 Russell Kans
Bennett Drlg Co 1381 E 26th St Tulsa 14 Okla
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Berry Drlg Co Box 67 Saint Jo Tex
Bickerstaff and Tibbets Drlg Co 406 N Marienfeld Midland Tex
Big Chief Drlg Co Box 8837 Oklahoma City 14 Okla
Big Seven Drlg Co 311 Wright Bldg Evansville Ind
Big '6' Drlg Co 225 Oil & Gas Bldg Houston 2 Tex
Big West Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Big X Drlg Co Inc 2905 First Natl Bldg Oklahoma City Okla
Bilbo-Redding Drlg Co Inc Box 21045 Houston Tex
Black Drlg Co 525 Petroleum Bldg Abilene Tex
Blount Drlg Co Inc 114 Central Bldg Midland Tex
Bodard Drlg Co 313 Masonic Bldg Shawnee Okla
Bolin Oil Co & D H Bolin 1120 Oil & Gas Bldg Wichita Falls Tex
Booker Drlg Co 2833 Gen Pershing New Orleans La
Ben F Brack Oil Co Inc 309-10 Brown Bldg Wichita Kans
Brack Drlg Co Inc Box 575 Fort Collins Colo
E G Bradham First Natl Bk Bldg El Dorado Ark
Brannon & Murray Drlg Co Box 672 Coleman Tex
Brantly Drlg Co Inc 109 Allen Bldg Midland Tex
D J Branyan Co Box 166 Cushing Okla
Branyan Drlg Co Box 166 Cushing Okla
C E Brehn Drawer 618 Mt Vernon Ill
Brewster-Bartle Drlg Co Inc 1919 Bk of Southwest Houston Tex
Brinkerhoff Drlg Co 870 Denver Club Bldg Denver 2 Colo
Zach Brooks Drlg Co Box 31 El Dorado Ark
Brown & Martin Drlg Co Box 731 Gainesville Tex
Brown & Thorp Drlg Co Box 1358 McCamey Tex
Layton Brown Drlg Co Box 185 Woodsboro Tex
Harry T Bryant Drlg Co Ltd Box 13364 Houston 19 Tex
Bryant-Hayward Drlg Co Box 4627 Oklahoma City Okla
Bueno Drlg Co 425 Continental Oil Bldg Denver Colo
Buick Drlg Inc Box 331 St John Kans
Bullard Drlg Co Inc Melrose Bldg Houston Tex
A O Bullock Drlg Co Box 821 Casper Wyo
Burnham & Robinson Drlg Co 4045 N Market St Shreveport La
Bury Drlg Co Box 316 Princeton Ind
Butler-Johnson Inc Box 306 Bossier City La
Buzzini Drlg Co Petroleum Center San Antonio 5 Tex
B G Byars Power Drlg Co 319 Citizens Bk Bldg Tyler Tex

C

C B Drlg Co 323 Petroleum Bldg Aiblene Tex
CBS Workover Co 1713 N Esperson Bldg Houston Tex
C H & C Drlg Co Box 4278 Oklahoma City 9 Okla
C K C Drlg Co 700 Oil & Gas Bldg Wichita Falls Tex
C-P Drlg Co Box 685 Pampa Tex
Cactus Drlg Corp of Tex Box 348 San Angelo Tex
Calco Drlg Co 1113 Continental Bk Bldg Ft Worth Tex
Calvert Drlg Inc 204-S Fair St Olney Ill
Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Camden Drlg Co Box 1418 Corpus Christi Tex
Camdrill International Inc c/o Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
J G Cantrell Drlg Co Box 1016 Ada Okla
Capitan Drlg Co Inc Box 671 Odessa Tex
Capitt Drlg Co 814-16 Union Center Wichita Kans
Frank Caraway Drlg Co Box 982 San Angelo Tex
Cardinal Drlg Co 420 Fourth St Bismarck N D
Carey & Parker Inc 300 N Jackson Odessa Tex
Carmack Drlg Co 1008 Mile High Center Denver Colo
Carpenter-Trant Drlg Co 321 C A Johnson Bldg Denver 2 Colo
Carroll Drlg Co Inc Box 337 Farmington N M
Carter Drlg Co 1640 W 34th St N Wichita Kans
Casey & Montgomery Box 1102 Bakersfield Calif
Casner & Bentz Box 666 Oildale Calif
Central Drlg Co Box 44 Fairfield Ill
Central Drlg Co 704 10th St Lawrenceville Ill
Chambless-Rosen Drlg Co Box 4294 Oklahoma City Okla
Chiles Drlg Co Box 949 Alice Tex
Cecil Chisler & Son Route 2 Fairview W Va
Choya Drlg Co Inc Suite A Ezell Bldg Midland Tex
Circle Drlg Co Inc 620 Pioneer Bldg Lake Charles La
Dan L Clark Drlg Co 819 Wilson Tower Corpus Christi Tex
Clark Drlg Co Box 1743 Billings Mont
Clark Fuel Prod Co Box 473 Mission Tex
Don Clawson Box 516 Ada Okla
Claypool Drlg Co St Elmo Ill
Clegg & Hunt 715 Houston Club Bldg Houston Tex
Clinch Drlg Co Box 27 Hazelhurst Miss
Coastal Drlg Co 7300 La Hore Rd Bakersfield Calif
Coastal Marine Drlg & Constr Co 450 Bk of the Southwest Bldg Houston 2 Tex
Colorado Wyoming Drlg Co 1119 Mile High Center Denver Colo
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
Comet Drlg Co Box 1143 OCS Lafayette La
Conrey Drlg Co 328 E Broadway Centralia Ill
Conroe Drlg Co Drawer 1741 Corpus Christi Tex
Continental Drlg Co 414 Shell Bldg New Orleans La
Continental Marine Expl Co Box 3050 Houston Tex
Continental Shelf Drlg Co 916 Richards Bldg New Orleans 12 La
Cooper Drlg Co 902 Staley Bldg Wichita Falls Tex
R A Cooper Drlg Co 711 Hulman Bldg Evansville Ind
J M Corbett 6282 E Marshall Tulsa Okla

Coroco Drlg Co 2807 Mercantile Bk Bldg Dallas Tex
Crawford Drlg Co Box 622 Shreveport La
Cree Drlg Co Inc Box 1821 Pampa Tex
Criswell Drlg Co Box 253 Arkansas City Kans
Cron & Gracey Corp 1100 Houston Club Bldg Houston Tex
Jess P Cross Drlg Contr 1216 Texas Graham Tex
Crow Drlg & Prod Co 2000 Beck Bldg Shreveport La
Crow Greyhound Drlg Co Inc Box 7334 Shreveport La
Milton Crow Inc 420 Commercial Natl Bk Bldg Shreveport La
Crowe Drlg Co 211 Perkins Bldg Duncan Okla
Crown Rigs Inc 2107 Bk of the Southwest Bldg Houston Tex
Sam E Crump Drlg Co 408 Union Bldg Midland Tex
Harry L Cullet Purefoy Hotel Talladega Ala
Cummins Drlg Co Altamont Ill

D

D-D Drlg Co Box 667 Olney Tex
D & J Drlg Co Rt 2 Box 219-A Okemah Okla
D-K Drlg Co Box 866 Cortez Colo
D & M Drlg Co Inc Box 247 Great Bend Kans
Clark Dale Drlg Co Inc 308 N Colorado Ave Midland Tex
Danforth Drlg Co 418 Kennedy Bldg Tulsa Okla
R A Davenport Drlg Contr 211 Perkins Bldg Duncan Okla
Davidson Drlg Co Inc 1004 Continental Life Bldg Ft Worth Tex
Davis & Bates Inc Milam Bldg San Antonio Tex
Edgar Davis Drlg Co 717 Citizens Bk Bldg Abilene Tex
Davon Drlg Co Box 1586 Oklahoma City Okla
Dearing Inc Box 655 Dallas Tex
Deepwater Expl Co 1109 Tex Natl Bk Bldg Houston Tex
Delaney Drlg Co Box 881 Ada Okla
M J Delaney Co 910 Dallas Fed Savings Bldg Dallas 1 Tex
Dellson Drlg Co U S Natl Bk Bldg Denver Colo
Del Mar Drlg Co 409 Oil Industries Bldg Corpus Christi Tex
Delta Drlg Co Box 2012 Tyler Tex
Delta Marine Drlg 407 California Co Bldg New Orleans La
Delta Overseas Drlg Co (Rome Italy) Box 2012 Tyler Tex
The Denver Co 1904 Great Plains Life Bldg Lubbock Tex
Denver Drlg Corp Box 669 Odessa Tex
R V Dillard Drlg Co Box 992 Duncan Okla
W L Dillier Box 341 Casey Ill
Dixon Drlg Co Box 2320 Abilene Tex
Doak Drlg Co Box 1108 Bristow Okla
Doc Drlg Corp Blackie Drlg Co Inc Neva-Andre Drlg Corp 210 Willow St Franklin La
Catline Dodson Co Inc Box 8503 Oklahoma City Okla
Donnell Drlg Co 607 Texas Bk Bldg Dallas Tex
Douglas Drlg Co Box 748 Oildale Calif
Douglas Drlg Co Box 1267 OCS Lafayette La
Drillers Inc 2005 Adolphus Tower Dallas Tex
Drlg & Expl Co Inc 600 Exchange Bk Bldg Dallas Tex
Drlg & Expl Co of Delaware Inc 600 Exchange Bk Bldg Dallas Tex
Drlg & Prod Co 2907 L St Bakersfield Calif
Drill Well Oil Co 1502 8th St Wichita Falls Tex
Drilvo (subs. of Drlg & Expl Co Inc) Hague Holland
Dual Drlg Co 606 City Natl Bk Bldg Wichita Falls Tex
Dublin-Kiel 203 Robertson Bldg Wichita Falls Tex
Dudley & Heath Drlg Co Box 428 Stillwater Okla
Dugger & Herring Drlg Co 203 Crescendo Bldg Abilene Tex
N V Duncan Drlg Co 303 Oil and Gas Bldg Oklahoma City Okla
Dunnam & Wyant Drlg Co 816 N. Jordan Liberal Kans
Durham Drlg Co Inc Box 204 Midland Tex
Dyer Drlg Co Box 338 Casper Wyo

E

E & H Drlg Co Box 1058 Graham Tex
Eagle Drlg & Developing Co Box 89 Natchez Miss
Eakle & Holder Drlg Co 116 Mulberry St Evansville Ind
T T Eason & Co Div of Eason Oil Co 1211 Colcord Bldg Oklahoma City 2 Okla
Eatmon Drlg Co Box 535 Kimball Neb
B F Edington Drlg Co Inc 447 N Market Shreveport La
Edwards & Bissett Inc 1912 N Esperson Bldg Houston Tex
Harry L Edwards Drlg Co Box 6825 Houston 5 Tex
King Edward (Edwards Drilg Co) Box 1140 Graham Tex
A W Eggleston Inc Box 425 Crowley La
Errol Elkins Drlg Co 460 Rio Grande St Eagle Pass Tex
Ellis & Gray 1536 Austin Colorado City Tex
Ellis Drlg Corp 1536 Austin Colorado City Tex
Empire Drlg Co 1507 Mercantile Bk Bldg Dallas Tex
Empire Drlg Co 400 Brown Bldg Wichita Kans
Empire States Drlg Corp 1020 Simms Bldg Albuquerque N M
Enterprise Oil Co 7440 La Hore Rd Bakersfield Calif
Ewing Drlg Co Box 807 Breckenridge Tex
Exeter Drlg Co Republic Natl Bk Bldg Dallas 1 Tex
Exploration Drlg Co 607 Natl Bk of Tulsa Bldg Tulsa Okla

F

Fain-Porter Drlg Corp 2410 First Natl Bldg Oklahoma City Okla
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Falco Drlg Co Inc Box 1255 Alice Tex
Falcon Seaboard Drlg Co Pan American Bldg Tulsa Okla
Felderhoff Bros Drlg Co Box 87 Muenster Tex
Fen-Par Expl Co Inc Box 282 Grand Haven Mich
Ferbanto Drlg Co Box 107 Carmi Ill
Field Drlg Co 1900 Milam Bldg San Antonio Tex
Jim Fish Drlg Co Box 655 Iowa Park Tex
Fitzpatrick Drlg Co 803 Wilson Tower Corpus Christi Tex
Fitzpatrick Drlg Co Inc Box 639 Casper Wyo
Fleeger Drlg Inc 271 Meadows Bldg Dallas 6 Tex
Flournoy Drlg Co Box 1578 Alice Tex
Flournoy-Haston Drlg Co Inc 1005 Davis Ardmore Okla
Folk Drlg Co 614 Main Yukon Okla
Foree Drlg Co 607 First Natl Bk Bldg Dallas Tex
Foretich Drlg Co Inc Box 709 Conroe Tex
Fortenbery Drlg Co Inc Box 273 Natchez Miss
Foster Drlg Co Box 751 Cushing Okla
4-J Drlg and Well Serv Co Box 471 Drumright Okla
Armstrong Fowler Inc 929 Oleander Bakersfield Calif
Lloyd R French Co 506 V & J Tower Midland Tex
Frio Drlg Inc 508 Driscoll Bldg Corpus Christi Tex
Frisbie Drlg Inc 402 Pan American Bldg Tulsa 3 Okla
Frizzell Drlg Co 108 NW 2nd St Oklahoma City Okla
Fryer & Hanson Drlg Co 2520 Republic Natl Bk Bldg Dallas Tex

G

Gabbert-Jones Drlg Co 514 Orpheum Bldg Wichita Kans
C S Garber & Sons Inc Boyertown Pa
Gardner Bros Drlg Co Inc 1708 Davis Bldg Dallas Tex
Buster Gardner Drlg Co Inc Box 281 New Iberia La
Garr-Woolley Oil Co 901 Cravens Bldg Oklahoma City Okla
Garvey Drlg Co Route 2 Great Bend Kans
Gary Drlg Co Box 58 Oil City La
General Drlg Co Colcord Bldg Oklahoma City Okla
General Geophysical Co 750 Houston Club Bldg Houston 2 Tex
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Gibson Drlg Co Box 1540 Kilgore Tex
Glenn Gillespie & Sons Box 907 Cushing Okla
Gilmour Drlg Co Box 1082 Alice Tex
Willard Gladson & Odstrcil Bros Drlg Co 2705 W 35th St Snyder Tex
C G Glasscock Drlg Co 1601 Wilson Tower Corpus Christi Tex
Glasscock-Wilson Inc 1604 Beck Bldg Shreveport La
Glendale Drlg Co 906 Hales Bldg Oklahoma City Okla
Glenn Drlg Co 38 Kennedy Bldg Tulsa Okla
F E Geber Drlg Co 3032 Cherry Ave Long Beach Calif
Goe Drlg Co Box 5 Perry Okla
Goff-Leeper Drlg Co Box 1749 Ardmore Okla
Golden Meadow Well Serv 616 Carondelet Bldg New Orleans La
Gold-Mar Drlg Co Box 732 Dewar Okla
Goldsmith Drlg Co Box 750 Duncan Okla
Gordon Drlg Co 1300 N Fancher Mt Pleasant Mich
T V Gorman 621 Staley Bldg Wichita Falls Tex
H O Grace Drlg Co 630 Wichita Natl Bk Bldg Wichita Falls Tex
Gracey-Hellums Corp 410 S Coast Bldg Houston 2 Tex
Burdette Graham 804 Driscoll Bldg Corpus Christi Tex
Graham-Michaelis Oil Co 211 N Broadway Wichita 7 Kans
Grannell Drlg Co Box 583 Casper Wyo
John Grappe Drlg Co Box 1186 Levelland Tex
Graves Drlg Co Box 583 Ardmore Okla
Gray Drlg Co 220 Wichita Natl Bk Bldg Wichita Falls Tex
Great Western Drlg Co Box 1659 Midland Tex
Green & Dreblow Drlg Co Box 1057 Barkersfield Calif
Greenland Drlg Box 518 Great Bend Kans
Greenwood Petroleum Management Inc Eureka Kans
Grey Wolf Drlg Co 1506 Bk of the Southwest Houston Tex

Guadalupe Drlg Co 2505 Princeton Ave Midland Tex
Roy Guffey Drlg Co 5543 Yale Blvd Dallas 6 Tex
Gulf Coast Drlg & Expl Inc Box 2367 Choctaw Sta Laurel Miss
Henry Gwaltney Drlg Co Box 289 Washington Ind

H

H & S Drlg Co 407 Tri State Ins Bldg Tulsa Okla
Hack Drlg Co Box 1636 Abilene Tex
John S Hagestad Drlg Co 3224 Gulf St Bakersfield Calif
Halbert Drlg Co 507 Citizens Bk Bldg Tyler Tex
Hale Bros Drlg Co 315-B City Natl Bldg Wichita Falls Tex
Joe Hale Drlg Co 315-B City Natl Bldg Wichita Falls Tex
Clyde Hall Drlg Co Inc Box 107 Sta B Bakersfield Calif
O E Hall Drlg Co 2008 Continental Natl Bk Bldg Ft Worth Tex
Hamilton-Powell Drlg Co Inc 1220 Hamilton Bldg Wichita Falls Tex
Hamman Oil & Ref Co Box 13028 Houston 19 Tex
Hap Drlg Co 501 First Natl Bldg Oklahoma City Okla
F E Hargraves & Son Drlg Co Box 573 Oil City La
Harkins & Co Box 1490 Alice Tex
Dave Harlin Drlg Co 2605 Avenue R Snyder Tex
Harms-Burt Drlg Co 823 Central Bldg Wichita Kans
Harper-Turner Drlg Co 904 Hightower Bldg Oklahoma City Okla
Harrell Drlg Co 1228 Bk of Southwest Bldg Houston 2 Tex
Harris Drlg Co Box 699 Grayville Ill
John W Harris Drlg Co 525 Wichita Natl Bk Bldg Wichita Falls Tex
C H Hartman 206 Security Bldg Sapulpa Okla
Harvey Drlg Co Box 418 Wichita Falls Tex
John Haseman Inc 419 Wilson Bldg Corpus Christi Tex
J W Hastings Drlg Co 722 Wichita Natl Bk Bldg Wichita Falls Tex
H F Hatcher & Son Drlg Co Box 164 Smackover Ark
Hawkins-Wilkins Prod Co 373 San Jacinto Bldg Houston Tex
Win Hawkins Drlg Co 373 San Jacinto Bldg Houston 2 Tex
Hayes & Sprague Inc 612 S Flower Los Angeles Calif
Hayward Drlg Co Box 295 Enid Okla
John Heard & Co Inc Rm 4 Elm Oil Bldg Tulsa Okla
Heathman Oil 1019 E 2nd St Wichita 7 Kans
Helmerich & Payne Inc First Natl Bldg Tulsa Okla
Henderson Drlg Corp 2208 N Esperson Bldg Houston 2 Tex
The Herb Expl Co 342 Lexington Ave Abilene Tex
Herndon Drlg Co Drawer 489 Tulsa Okla
Herring & Davis 607 Kennedy Bldg Tulsa Okla
Maxwell Herring Drlg Corp Box 1122 Kilgore Tex
B M Hester Box 2588 Wichita Falls Tex
Hewgley Drlg Co 704 Wilco Bldg Midland Tex
Hewit-Gulick Drlg Co 240 Silver State Bldg Denver 2 Colo
Highland Drlg Co Box 671 Odessa Tex
Highland Oil Box 263 Jasper Ind
Hilburn Industries Inc Ricou-Brewster Bldg Shreveport La
Hill Drlg Co Box 532 Conroe Tex
J E Hillier Box 67 Pleasanton Tex
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C F Hills Drlg Co Box 2158 Pampa Tex
Hissom Drlg Co 1327 Wilco Bldg Midland Tex
Holliman Drlg Co 712 Fidelity Union Life Bldg Dallas Tex
Holm Drlg Co Box 7246 Tulsa Okla
Holmes Drlg Co 1045 San Jacinto Bldg Houston Tex
Holt Brothers Drlg Co Box 236 Pampa Tex
W C Holt Drlg Co 920 Enterprise Bldg Tulsa Okla
R L Horn & Son Drlg Co Pawnee Okla
Hose-Austin Drlg Corp Box 1067 Casper Wyo
Housh Drlg Co 586 Gulf Bldg Addn Houston 2 Tex
Houston Oil Well Serv Co 504 Waugh Dr Houston 19 Tex
Howell & Howell 1610 Life of America Bldg Dallas Tex
Hull Oil Co 214 Panhandle Bldg Wichita Falls Tex
Hunt Drlg Co Inc 634 Wilson Bldg Corpus Christi Tex
Hunter Bros 509 First Natl Bldg Wichita Falls Tex
T F Hunter Estate 509 First Natl Bldg Wichita Falls Tex
Hupp & Hume Box 616 Owensboro Ky
I J Huval Well Serv Co Box 261 Pampa Tex
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I

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Donald T Ingling 623 First Natl Bk Bldg Wichita 2 Kans
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Iron Drlg Co 1206 Philtower Bldg Tulsa 3 Okla
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J

J & C Drlg Co Box 552 Refugio Tex
J & J Drlg Co Box 150 Holdenville Okla
J & L Drlg Co Ltd 2005 Adolphus Tower Bldg Dallas Tex
J M C Drlg Interests 6282 E Marshall Tulsa Okla
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Jackson Oil Co Box 2347 Longview Tex
Charles M Jameson Box 532 Vernal Utah
Jennings Drlg Co 612 City Natl Bk Bldg Wichita Falls Tex
Jett Drlg Co Inc Box 1832 Shreveport La
Johnn Drlg Co 711 Fair Bldg Ft Worth Tex
Al Johnson Drlg Co Rt 12 Box 440 Oklahoma City Okla
Johnson-Bates Drlg Co Box 425 Konawa Okla
Johnson Drlg & Serv Co Box 3 Magnolia Ark
Johnson Drlg Co 634 Petroleum Bldg Tyler Tex
Fred Johnson Drlg Co 2790 Cherry Ave Long Beach Calif
Don Johnston Drlg Co 825 Petroleum Club Bldg Denver Colo
Buck Jones Drlg Co Box 1085 McCamey Tex
J E Jones Drlg Co Box 2218 Midland Tex
Jones Well Serv Co Box 1547 Abilene Tex
Woody Jones Drlg Co 408 E Main St Olney Ill
Julkirk Corp 506 V & J Tower Midland Tex
Justiss-Mears Oil Co Box 396 Jena La

K

K & E Drlg Inc 719 Union Center Bldg Wichita 2 Kans
Keating Drlg Co 510 Natl Bk of Tul Bldg Tulsa Okla
Kee & Simpson Drlg Co 417 S Hill St Los Angeles 13 Calif
K L Kellogg & Sons Box 510 Compton Calif
Kelly Drlg Co Box 1126 Houma La
Kendall-Davis Drlg Co Inc 201 SE 1st St Evansville Ind
Kendrick Bros Box 402 Vivian La
Kent & Preston 425 Sayles Blvd Abilene Tex
Kerr-McGee Oil Industries Inc Kerr-McGee Bldg Oklahoma City Okla
Kersey & Co Box 305 Artesia N Mex
Kilroy Drlg Co 2306 Bk of Southwest Bldg Houston Tex
Carl B King Drlg Co of Tex Box 270 Midland Tex
King-Phillips Inc 1109 Continental Natl Bk Bldg Ft Worth Tex
Kingery Drlg Co Inc Box 97 Saint Jo Tex
Kirby Oil Ind 5107 Center St Omaha 6 Neb
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Kirkpatrick Oil Co 1300 N Broadway Okla City Okla
A F Knappenberger and K & H Drlg Co 427 Elm St Graham Tex
Knight Drlg Co Box 1332 Bakersfield Calif
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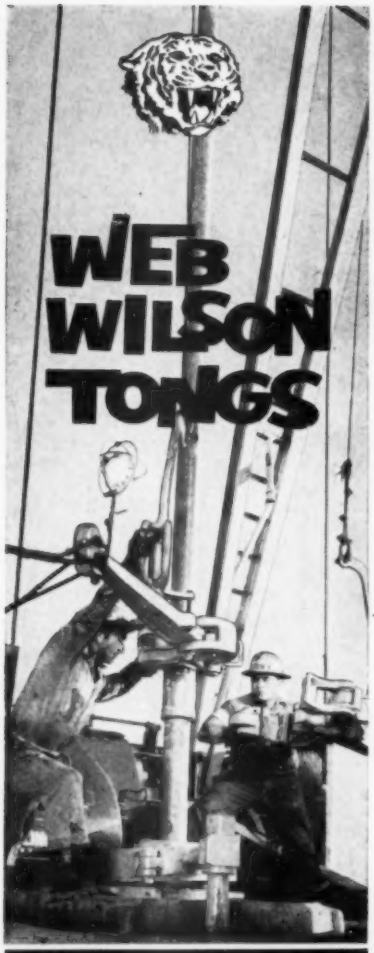
L

L & N Drlg Co 6709 Canal Blvd Shreveport La
Ralph G Ladd Box 5 Haskell Okla
Lake Charles Drlg Inc Rt 1 Box 891 Lake Charles La
LaMac Oil Co 104 S Main St Taylorville Ill
Lamar Drlg Corp Box 4128 Centenary Sta Shreveport La
Larco Drlg Co Box 3499 Jackson Miss
Latexo Drlg Co Inc 2212 Adolphus Towers Bldg Dallas Tex
J W Lawrence Box 942 Conrad Mont
Joe Lawrence Drlg Co Box 1021 Ada Okla
Roy Lawrence Drlg Co Box 306 Pawnee Okla
Layton and Newell Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Leatherwood Drlg Co Box 925 Jacksboro Tex
LeCune Oil Corp Box 804 Jefferson Tex
Lee Drlg Co 1007 Philtower Bldg Tulsa Okla
D B Lesh Drlg Co Box 505 Mattoon Ill
Lewis Bros Inc 320 Mile High Center Denver 2 Colo
Lewis Drlg Co 915 Union Center Wichita Kans
Will I Lewis Drlg Co 425 Continental Oil Bldg Denver Colo
Liberty Drlg Corp Box 14308 Houston Tex
Lincoln Drlg Co 403 Oil & Gas Bldg Oklahoma City Okla
Ted Lindsay Drlg Contr Box 190 Mt Vernon Ill
M M Lindsey Drlg Co 4748 Airline Hwy Baton Rouge La
H J Lininger Box 37 Upper Sandusky Ohio
Lin-Mour Drlg Co Oil & Gas Bldg Wichita Falls Tex
Livermore Drlg Co 406 Lubbock Natl Bk Bldg Lubbock Tex
Llano Drlg Co 301 V & J Tower Bldg Midland Tex
Lohmann-Johnson Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Charles E Long Jr Inc Box 961 Midland Tex
Longhorn Drlg Corp Box 546 Three Rivers Tex



Heat treated manganese-molybdenum steel for strength—"spiral" hinge pin design for equalizing stresses—perfect balance for easy handling.

Do your crews feel SAFE when breaking out the largest, tightest drill collars and tool joints?

The strongest tong ever made is shown on Page 5486 of the WEB WILSON (or Composite) Catalog

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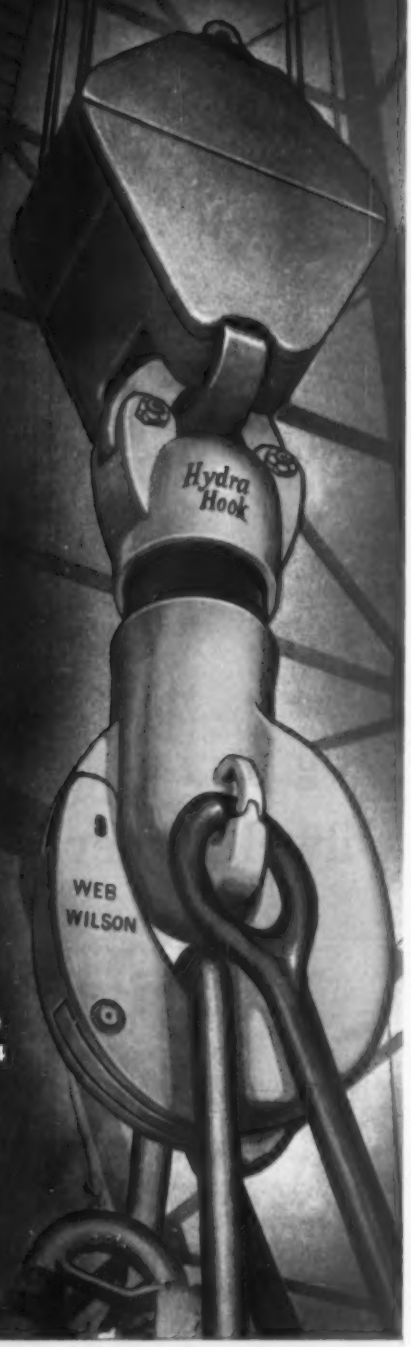
Short and streamlined, with plenty of weight to fall fast and free.

An oil bath permanently lubricates bearings and springs and ensures long, low-cost service.

How do HYDRA HOOKS prevent damage to tool joint threads and sealing shoulders?

Any Web Wilson man has the answer, or look on Page 5494 of the Web Wilson (or Composite) Catalog.



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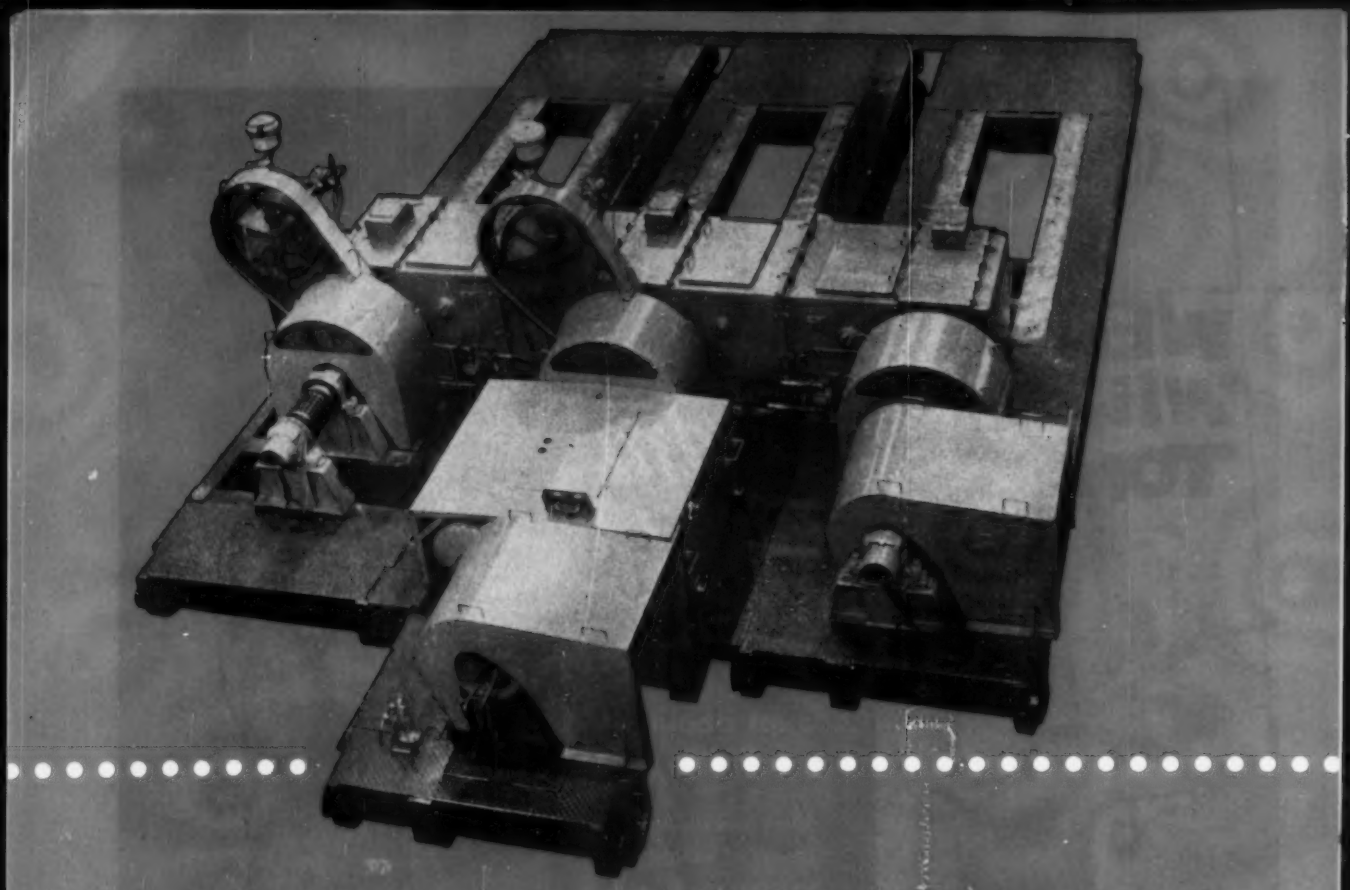

Rig up fast and cut maintenance costs with "Oilwell's" new SECTIONALIZED 1600 drive

THIS NEW DRIVE consists of three primary sections which can be designated as front, intermediate and rear. By mounting each shaft-and-case assembly on the same skid base with its associated engine, alignment is permanently maintained. This arrangement holds the number of loads to a minimum.

This illustration shows the basic three-engine, two-pump drive. The second pump drive can be omitted when not required, by substituting a different intermediate section. The 1600 drive can be furnished for two, three, four or five engines.

FEATURES INCLUDE:

1. **Rugged 18"-deep** frame construction.
2. **Machined** engine mounting surfaces.
3. **High accessibility** of working parts.
4. **Gap-mounted** cut-off clutches.
5. **Oil-tight** metal-to-metal chain case joints.
6. **Outside-mounted** chain oiling pumps.
7. **Grease-lubricated bearings.**

For further information, see your "Oilwell" representative.

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M

M-H-O Drlg Co Box 297 Cut Bank Mont
MIM Drlg Corp 1401 Majestic Bldg San Antonio Tex
M & J Inc 3612 W Wall Midland Tex
Mac Drlg Co Box 2972 Houston Tex
Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Makin Drlg Co Box 1628 Hobbs N Mex
Mallard Drlg Co 1016 Union Natl Bk Bldg Wichita Kans
Mallonee Drlg Co Inc 820 Union Center Wichita Kans
R L Manning Co 318 Continental Oil Bldg Denver Colo
Marex Inc 112½ Del Laquara St Santa Barbara Calif
Marine Drlg Inc 212 Balter Bldg New Orleans La
Maritzky & Bibby Box 509 Homer La
M L (Mike) Marrs Drlg Co Box 985 Drumright Okla
Martin & Holmes Oil Well Serv Co 4730 Ayers Corpus Christi Tex
Lubie Martin Drlg Co 2052 Harvard Houston Tex
Maxwell Drlg Co Box 846 Coleman Tex
M Mazzarino 104 W Broadway Centralia Ill
McAlester Fuel Co Box 210 Magnolia Ark
Gabe McCall Drlg Co Box 2068 Casper Wyo
McCalman Drlg Co Inc Box 602 Homer La
McClure Oil Co Box 147 Alma Mich
McCutchen & Graham 409 Oil & Gas Bldg Wichita Falls Tex
Gene McCutchin Box 1585 Dallas Tex
McDaniel Drlg Co 205 C A Johnson Bldg Denver 2 Colo
B L McFarland Drlg Corp 3612 W Wall Midland Tex
B L McFarland Inc 3612 W Wall Midland Tex
W H McGarr Industries Box 472 Eagle Pass Tex
J R McGill 509 Amarillo Bldg Amarillo Tex
McGoldrick & Watson Drlg Co 405 Beck Bldg Shreveport La
B M McGraw Drlg Contr 4412 N Western Oklahoma City Okla
McQueen & Stout Drlg Co 1113 Ft Worth Natl Bk Bldg Ft Worth 2 Tex
Meadows & Walker Drlg Co 500 San Jacinto Bldg Houston 2 Tex
Melco Drlg Co Box 1360 Seminole Okla
Mercury Drlg Corp 1205 Beck Bldg Shreveport La
Meredith & Co 1418 Bk of the Southwest Bldg Houston Tex
Meredith Drlg Co 419 City Natl Bldg Wichita Falls Tex
Ward S Merrick Box 971 Ardmore Okla
Mesker Drlg Co 1129 E 15th St Tulsa Okla
Midwestern Drillers Inc 1206 Mid-Continent Bldg Tulsa 3 Okla
J Conley Miles Drlg Co 1874 Jackson St Abilene Tex
Milestone Drlg Co Box 2745 Midland Tex
Milhoan Drlg Co Box 948 Tulsa Okla
Miller & York Box 936 Bakersfield Calif
Miller Bros & Bowling Box 611 Alice Tex
Gene Miller Inc Box 238 Lawrenceville Ill
J E Miller Drlg Contr Box 1581 Abilene Tex
Miracle & Wooster Drlg Co Box 233 Vernal Utah
Miracle-Fifer Drlg Co 1636 Welton St Denver 2 Colo
Mobile Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kans
Monroe Drilling Co Inc Box 490 Monroe La
Montgomery Drlg Co Box 747 El Dorado Ark
J S Montgomery 103 NW 44th St Oklahoma City Okla
Moore & Moore Drlg Co Box 29 Abilene Tex
Lamar H Moore Drlg Co Box 29 Abilene Tex
Mora Drlg Co 1908 First Natl Bldg Tulsa Okla
Moran Bros Inc 1200 Oil and Gas Bldg Wichita Falls Tex
E F Moran Inc 1805 Natl Bk of Tulsa Bldg Tulsa 3 Okla
E W Moran Drlg Co 500 First Natl Bk Bldg Wichita Falls Tex
Moran Oil Prod & Drlg Corp Box 1718 Hobbs N Mex
Dave Morgan Drlg Co Box 820 Blackwell Okla
Pete Morris Drlg Co Box 733 Ada Okla
Morrison Drlg Co Inc Box 583 Casper Wyo
Mountain States Drlg Co Inc 622 Patterson Bldg Denver Colo
Mobile Offshore Co 743 San Jacinto Bldg Houston 2 Tex
Murphy & McKernan Box 169 Pampa Tex
Muskegon Development Co 432 Lyman Bldg Muskegon Mich
Myers Drlg Serv 2117 Bank St Bakersfield Calif

N

Neal Drlg Co Box 3186 Victoria Tex
Nebraska Drillers Inc Box 805 Grand Island Neb
Needham Drlg Co Box 1285 Artesia N Mex
Nelson Drlg Co 300 W Main Ardmore Okla
Nemaha Oil Co Mercantile Bk Bldg Dallas Tex
Newton Drlg Co Box 1104 Coalinga Calif
Nicklos Drlg Co 518 City Natl Bk Bldg Houston Tex
Nichols Drlg Co Box 1032 Duncan Okla
The Noah Petroleum Co Box 192 Albion Ill
George Noland Drlg Co Inc 823 S Detroit Ave Tulsa 20 Okla
Norman Drlg Corp 1141 Butternut St Abilene Tex
Norton Drlg Co 542 Natl Bk of Commerce Bldg New Orleans 12 La
William A Norton 6516 NW Grand Blvd Oklahoma City Okla
Norwood Drlg Co 700 Wichita Natl Bk Bldg Wichita Falls Tex
The Novak Drlg Co Box 2147 Tulsa Okla
Nuckolls-Bell Drlg Co 1255 First Natl Bldg Oklahoma City 2 Okla
Nye & Snell Drlg Co 208 Patterson Bldg Denver Colo

O

Ocean Drlg & Expl Co 918 Carondelet Bldg New Orlean La
Oien Oil Corp Box 2235 Cut Bank Mont
Olds & Wrather Drlg Co Box 113 Casper Wyo
W B Omohundro Box 774 Wichita Falls Tex
Oney Drlg Co Box 425 Graham Tex
Orm Drlg Co 421 M & P Bk Bldg Sherman Tex
Ormand Bros Drlg Co Box 1469 Odessa Tex
Ormand Drlg Co Inc Box 1469 Odessa Tex
O'Rourke-McGirl Drlg Co 632 Natl Bk of Tul Bldg Tulsa Okla
Overby Drlg Co Inc Box 248 Nowata Okla
Owen Drlg Co Box 1423 OCS Lafayette La

P

Paco Petroleum Corp Box 347 Mt Carmel Ill
Paine Drlg Co 301 Insur-O-Medic Bldg Dallas Tex
Parker Drlg Co 418 Natl Bk of Tul Bldg Tulsa Okla
Patco Drilling Contr Box 322 Stillwater Okla
Patton Drlg Co Inc Orpheum Bldg Wichita Kans
Payne Bros Drlg Co 1411 10th St Lawrenceville Ill
Peak Drlg Co Inc 1019 Central Bldg Wichita Kans
Willard Pease Drlg Co Box 1532 Grand Junction Colo
Pegg Bros Drlg Co 1204 Natl Bk of Commerce Bldg San Antonio Tex
Penrod Drlg Co 418 Market St Shreveport La
Perforaciones Delta C A Apartado 9138 Caracas Venezuela
Perkins Bros Drlg Co Box 1232 Duncan Okla
Perrine & Perrine Drlg Contr Box 87 Salem Ill
Petersen Petroleum Corp 836 Olive Shreveport La
Petro Drlg Co Inc Box 339 Mt Vernon Ill
Petroleum Drlg Co 200 Petroleum Bldg San Angelo Tex
H F Pettigrew 836 Republic Natl Bk Bldg Dallas Tex
Pickrell Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kans
Louis Pitcock Drlg Co Box 25 Graham Tex
Jack Plemons Drlg Co Box 1493 Artesia N Mex
Pool & Gerlich Drlg Co Box 1940 San Angelo Tex
Fred Pool Drlg Co 3106 Lockheed Midland Tex
Poteet Wysor & Eckles Inc Box 508 Holdenville Okla
Powell Drlg Co 412 Union Center Bldg Wichita Kans
Graham Powell Drlg Co 129 N Sycamore St Centralia Ill
The Power Rig Drlg Co Box 1436 OCS Lafayette La
Prairie Drlg Co Box 2068 Casper Wyo
Prime Drlg Co 814-16 Union Center Wichita Kans
Prince Marine Drlg & Expl Co 434 Bk of Southwest Bldg Houston Tex
Princeton Mining Co 111 N 7th St Terre Haute Ind
Producers Drlg Co Inc 927 Natl Bk of Commerce Bldg New Orleans La
Pyburn Drlg Co Box 4276 Shreveport La

R

R-G Drlg Co 403 City Natl Bk Bldg Wichita Falls Tex
R W I T Drlg Co 506 Diamond St Holdenville Okla
Frank Raiborn Drlg Co 35 Garden Rd San Angelo Tex
Ramey Well Serv Suite 401P Robertson Bldg Wichita Falls Tex
G H Ray Well Serv Box 68 Cement Okla
Jack and H P Read Box 212 Scottsville Ky
Reading & Bates Co de Venezuela 1502 Philtower Bldg Tulsa 3 Okla
Reading & Bates Inc 1502 Philtower Bldg Tulsa Okla

Reading & Bates Offshore Drlg Co 1502 Philtower Bldg Tulsa 3 Okla
Rebstock & Reeves Drlg Co 450 Saratoga Bldg New Orleans La
Red River Drlg Co Cook Bldg Breckenridge Tex
Reed Drlg Co Inc 1209 Atlas Bldg Tulsa Okla
Reserve Drlg Co Inc 625 Union Center Bldg Wichita 2 Kans
Reserve Drlg Co Inc Drawer 1612 Casper Wyo
Rex & Morris Drlg Co Box 334 El Dorado Kans
Rheay & Reynolds Drlg Co 404 Petroleum Bldg Abilene Tex
Rhodes & Hicks Drlg Corp Box 1395 Alice Tex
Rhodes Drlg Co Box 239 Abilene Tex
Riceland Corp Box 747 Dallas Tex
Marvin S Ridgeway Box 943 Beeville Tex
Riley & Gammon 509 N Railroad St Madisonville Ky
The R W Rine Drlg Co 420 Union Center Wichita Kans
Robinson Bros Drlg Co Box 430 Borger Tex
Robinson Drlg Co Box 153 Abilene Tex
Robinson-Wehmeyer 470 San Jacinto Bldg Houston Tex
Rocket Drlg Co 2099 E 27th St Long Beach Calif
Rocky Mountain Drlg Co 550 S Flower St Los Angeles Calif
Roden & McRae Drlg Corp Box 2286 Casper Wyo
Dwight M Ross Drlg Co Hamilton Bldg Wichita Falls Tex
R Benton Ross Inc 403 Robertson Bldg Wichita Falls Tex
Don M Rounds Co Inc 925 Petroleum Club Denver 2 Colo
Rowan Drlg Co Inc Drawer 12247 Fort Worth 16 Tex
J W Rudy Box 684 Clay City Ill
Ruhl Drlg Co Inc 1621 Bk of Southwest Bldg Houston 2 Tex
Rupp-Ferguson Oil Co 522 Union Center Bldg Wichita Kans
A D Rushing Inc 523 W 6th St Los Angeles 14 Calif
Russell & Russell Drlg & Prod 621 Lindsay St Gainesville Tex
Paul F Rutledge Box 2239 Santa Fe N Mex

S

Sabre Drlg Co 222 Hughes Bldg Cushing Okla
St John Drlg Co Box 639 Ballinger Tex
Salt Dome Prod Co 737 Texas Natl Bk Bldg Houston 2 Tex
Santa Fe Drlg Co Box 310 Whittier Calif
Santa Maria Drlg Corp 2875 Cherry Ave Long Beach 6 Calif
Scat Drlg Co Inc Box 787 Drumright Okla
Schafer Drlg Co 2400 Liberty Bk Bldg Oklahoma City Okla
Schimmel Drlg Co 2121 Alamo Natl Bldg San Antonio Tex
A L Schlaikjer Box 761 Newcastle Wyo
Scooter's Drlg Serv 1215 Sklar Bldg Shreveport La
Paul Septer Drlg Co 521-22 Union Natl Bk Bldg Wichita Kans
Seran & Howard Drlg Co Box 110 Okemah Okla
SeRoBee Drlg Co Inc 521-22 Union Natl Bk Bldg Wichita Kans
Service Drlg Co 515 Kennedy Bldg Tulsa Okla
Harold Shappell Drlg Co 316 City Natl Bldg Wichita Falls Tex
Sharp Drlg Co Box 1271 Midland Tex
Sheets & Walton Drlg Co Box 152 Breckenridge Tex
Shelley-Miller Drlg Co 205 Miller Bldg Wichita Kans
Sherin Drlg Co Inc 1709 First Natl Bldg Oklahoma City Okla
Shields Drlg Co Inc Shields Bldg Russell Kans
Shields Oil Producers Shields Bldg Russell Kans
Shoreline Drlg Co Inc 1203 Beck Bldg Shreveport La
Shulman Bros Box 191 Vandalia Ill
Signal Drlg & Expl Inc 203 Mayo Bldg Tulsa Okla
Signal Oilfield Serv 203 Mayo Bldg Tulsa Okla
Joe Simpkins 6421 Easton Ave St Louis 14 Mo
Skinner & McDougal Drlg Co Box 8774 Oklahoma City Okla
Don Slape Drlg Co Box 432 Olney Ill
Smiley & Little Drlg Co 1635 SE 29th St Oklahoma City Okla
Smith & Breyer Suite 152 Meadows Bldg Dallas 6 Tex
K Smith Cable Tools 1801 Van Buren Great Bend Kans
H R Smith Drlg Contractor P O Box 98 Alice Tex
James Smith Drlg Contr Box 33 Mertzon Tex
Ray Smith Drlg Co Simons Bldg Dallas Tex
Sojourner Drlg Corp Box 679 Abilene Tex
Sooner Drlg Co 412 Federal Natl Bk Bldg Shawnee Okla
Southeastern Asia Drlg Co 901 Employers Ins Bldg Dallas Tex
Southeastern Drlg Corp 901 Employers Ins Bldg Dallas Tex
Southland Drlg Co 435 Milam Bldg San Antonio Tex
South State Drlg Corp Mt Vernon Ind
South States Drlg Co Box 2347 Longview Tex
Southworth & Wood Inc 1021 San Jacinto Bldg Houston Tex
J D Sprecher Box 299 Casper Wyo
Star Drlg Co Box 326 Wilson Okla
H J Steward Box 1031 Taylor Tex
Stewart & Gouger Drlg Co 505 Alamo Natl Bldg San Antonio 5 Tex
Stice Drlg Co Box 678 Beeville Tex
Jack L Story Box 1073 Dallas Tex
Stouder Drlg Co 208 SE Riverside Dr Evansville Ind
Harold L Strader Drlg Co 3901 Mt Vernon Houston 6 Tex
Strain Drlg Co 608 Patterson Bldg Denver Colo
Strait Drlg Inc Box 90 El Dorado Kans
C W Stratman Drlg Co 620 S 30th St Mattoon Ill
Stroube Drlg Co Box 730 Corsicana Tex
Summit Drlg Corp 414 Atlas Life Bldg Tulsa Okla
The Sun Drlg Co 2975 Wilshire Blvd Los Angeles 5 Calif
Sunnyland Contracting Co Inc Box 388 Rayne La
Sutton Drlg Co Box 6446 San Antonio Tex
Swett Bros Drlg Co Box 331 Bakersfield Calif
Symons Drlg Co 999 Houston Club Bldg Houston 2 Tex

T

T & H Corp 111 N 7th St Terre Haute Ind
Target Drlg Corp 201 Enterprise Bldg Tulsa Okla
Taylor Expl Co Inc 2118 Welch Ave Houston Tex
W P Taylor Drlg Co 1429 Bk of the Southwest Houston Tex
Temple Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Tennant Drlg Co Rivoli Bldg Blackwell Okla
Terminal Drlg & Prod Co 1240 Blinn Ave Wilmington Calif
Texita Oil Co 812 Milam Bldg San Antonio 5 Tex
Tex-Mex Drlg 1211 Fidelity Union Life Bldg Dallas Tex
Thomas & Billups Drlg 809 Citizens Bk Bldg Abilene Tex
Thompson Drlg Co Box 577 Comanche Okla
Thrasher Drlg Co 1602 Beck Bldg Shreveport La
Three Sisters Drlg & Prod Co Box 1013 Albany Tex
Timberland Expl Co 366 San Jacinto Bldg Houston 2 Tex
Trachta Drlg Co Box 67 Muenster Tex
J C Trahan Drlg Contr Inc 1203 Beck Bldg Shreveport La
Transit Corp 1516 Liberty Bk Bldg Oklahoma City Okla
Trant Drlg Co 1201 Peoples Bk Bldg Tyler Tex
Travis Drillers Inc Box 1097 Austin Tex
Treasure State Drlg Co Box 1712 Great Falls Mont
Triad Drlg Co 120 Featherston Bldg Wichita Falls Tex
Trimble Drlg Co Inc Box 459 Magnolia Ark
Trinity Drlg Co 1205 Mercantile Securities Bldg Dallas Tex
Trio Drlg Co 3013 Nussbaumer Dallas 26 Tex
Tri-Service Drlg Co Box 1785 Midland Tex
Triton Drlg Co Inc Box 13275 Houston 19 Tex
Troop Drlg Co Box 145 St Elmo Ill
Troup & Suttles Inc 506 Diamond Holdenville Okla
True Drlg Co Drawer 1612 Casper Wyo
Tucker Drlg Co Box 270 San Angelo Tex
Goal Tullous & Co 206 N Big Spring Midland Tex
Turnbull & Zoch Drlg Co Box 2248 Corpus Christi Tex
C D Turner Drlg Co 501 Permian Bldg Big Spring Tex

U

U & E Drlg Co Box 323 Sullivan Ind
Rip C Underwood 553 First Natl Bk Bldg Amarillo Tex
Union Rotary Corp 1104 N Mission St Mt Pleasant Mich
Unit Drlg Co Box 599 Bristow Okla
United Drlg Co 8750 Holloway Dr Los Angeles 46 Calif
Urice Drlg Co 615 Ft Worth Club Bldg Ft Worth Tex

V

V S & S Drlg Co 1004 Ridgley Bldg Springfield Ill
V-T Drlg Co 711 Hulman Bldg Evansville Ind
Veeder Supply & Dev Co Box 201 Cherryvale Kans
Viersen & Cochran Box 280 Okmulgee Okla
Viking Drlg Co 102 W Crockett St San Antonio 5 Tex

W

W L B Drlg Co 6635 Chocolate Bayou Rd Houston 21 Tex
Wagner & Wyant Drlg Co Inc 414 Petroleum Bldg Amarillo Tex
Walker Brothers Drilling Co 2101 Christine St Pampa Tex
Walters Drlg Co 510 Orpheum Bldg Wichita Kans
Walters Drlg Co Inc 4114 McMillan Dallas 6 Tex
Rusty Walters Drlg Co Box 304 Bakersfield Calif
Walton Drlg Co Box 241 Fairfield Ill
Ward Drlg Co 106 Oil & Gas Bldg Wichita Falls Tex
Tommy Ward Drlg Co 1415 Liberty Bk Bldg Oklahoma City Okla
Warren Drlg Co 1012 Mayo Bldg Tulsa 3 Okla
Warton Drlg Co Box 2807 Odessa Tex
C B Webster Drlg Co 609 San Jacinto Bldg Houston Tex
Webster Drlg Co 424 S Cheyenne Tulsa Okla
Dick Wegener Drlg Contr 1820 First Natl Bldg Oklahoma City Okla

Well Drillers Inc 2001 City Natl Bk Bldg Houston Tex
Wes-Mor Drlg Inc Box 1169 Graham Tex
Art West Drlg Co 305 O'Michael Bldg Odessa Tex
West Central Drlg Co 717 Citizens Bk Bldg Abilene Tex
Western Drlg Co Inc 902 Lubbock Natl Bk Bldg Lubbock Tex
Western Serv Drlg Co Inc Box 1428 Odessa Tex
Wes-Tex Drlg Co Box 2058 Abilene Tex
Chester H Westfall Drlg Co 1202 Hunt Bldg Tulsa Okla
Chet Whaley Well Serv Co Inc 6006 Milart St Houston 21 Tex
Wheless Drlg Co Box 368 Shreveport La
Wilbanks & Rutter Drlg Co 2200 Scurry St Big Spring Tex
A W Williams Drlg Co Inc 411 Virginia St Mobile Ala
Williams Drlg Co Inc Box 851 Springhill La
Kidd Williams Drlg Corp 205 Kennedy Bldg Tulsa Okla

Walter W Willis 813 Broadway Mt Vernon Ill
Wilson Drlg Co Inc Box 933 Jackson Miss
C R Winn Drlg Contr Box 331 Salem Ill
Wise Drlg Account Box 297 Tyler Tex
Woodson Prod Co 412 Exposition Dallas 26 Tex

Y

Yarborough Drlg Co 735 Wilson Bldg Corpus Christi Tex
S P Yates Drlg Co 311 Carper Bldg Artesia N Mex
Marshall R Young Drlg Co Box 712 Brookhaven Miss

Z

Zapata Off-Shore Co 2218 First City Natl Bk Bldg Houston Tex

U. S. Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALABAMA						
Mobile County						
Zach Brooks Drlg Co	4	gas	1350	Brwstr N-75	1350	12,000
	7	dsl	1350	Brwstr N-75	1350	12,500
Jett Drlg Co Inc	104	dsl	—	—	1000	12,000
	106	dsl	—	—	1000	13,000
Justiss-Mears Oil Co Inc	1	dsl	350	Emsco GB-800	900	13,000
	7	dsl	700	Emsco J-750	1000	11,500
ARIZONA						
Apache County						
D-K Drlg Co	1	gas	675	Natl 50	675	7,500
ARKANSAS						
Columbia County						
E G Bradham	1	LPG-gas	—	Crdwll S	180	6,000
	2	LPG-gas	—	Brwstr N-4	280	7,000
L & N Drlg Co	2	btne	226	Wlsn Super	110	2,500
Maritzky & Bibby	2	gas	330	Crdwll	145	3,000
McAlester Fuel Co	—	dsl	—	Crdwll Trlrg	275	5,500
	—	btne-gas	—	Emsco GC-500	820	11,000
Franklin County						
Scooter's Drlg Serv	3	dsl	600	Brwstr N-55	600	6,000
Johnson County						
B M McGraw Drlg Contr	1	gas-gaso	900	Brwstr N-7	900	8,000
Lafayette County						
Hilburn Industries Inc	2	gas	550	Wlsn	—	10,000
Montgomery Drlg Co	2	gas-btne	415	Brwstr N-55	—	7,500
Logan County						
Parker Drlg Co	5	gas	—	Natl L-50	700	9,000
	30	gas	—	Natl L-50	700	9,000
Viersen & Cochran	10	gas	325	Natl 50	450	8,800
Miller County						
Barnwell Drlg Co Inc	7	dsl	600	Brwstr N-75	600	10,000
Milton Crow Inc	6	dsl	260	Brwstr N-4	260	5,500
Mercury Drlg Corp	2	gas	200	Wlsn Mogul	200	4,000
Ouachita County						
H F Hatcher & Son	2	gas-gaso-btne	250	Crdwll S-350	250	5,500
L & N Drlg Co	1	btne	226	Brwstr N-3	165	3,500
Saline County						
Walters Drlg Co Inc	3	gas	130	Mayhew	130	1,000
	4	gas	130	Mayhew 1000	130	600/2⅛"
	5	gas	150	Mayhew 1000	150	600/2⅛"
	7	gas	175	Mayhew 1000	175	900/2⅛"
	8	gas	220	Mayhew 1000	220	600/2⅛"
	11	gas	150	Mayhew 1000	150	600/2⅛"
	13	gas	200	Mayhew 1000	200	600/2⅛"
Union County						
H F Hatcher & Son	1	gaso-gas-btne	225	Crdwll RL-597	165	4,000
Mercury Drlg Corp	1	gas	200	Ideco H-20	200	3,500
Trimble Drlg Co Inc	1	dsl-btne	240	Brwstr N-4	310	5,000
	2	dsl	310	Emsco GB-250	310	6,500
CALIFORNIA						
Fresno County						
Camay Drlg Co	1	gas	1075	Emsco J-1000	1000	12,000
Green & Dreblow Drlg Co	—	dsl	600	Wlsn Giant	600	7,500
John S Hagestad Drlg Co	1	dsl	570	Emsco GB-350	400	7,000
Hayes & Sprague Inc	1	gas	1050	Wlsn Titan	1050	13,000
Miller & York	F	dsl	735	Emsco GA-500	550	8,000
Rocky Mountain Drlg Co	14	gas	1200	Emsco J-1250	1500	20,000
Rusty Walters Drlg Co	1	dsl	300	Wlsn Mogul	300	7,000/4"
Glenn County						
B J & M Drlg Co Ltd	1	dsl	600	Unit 35-D	400	7,000
	2	gas	450	Emsco GA-500	450	7,500
Coastal Drlg Co	1	dsl	1500	Emsco J-1250	1920	16,000
Armstrong Fowler Inc	1	dsl	610	Natl 50-CA	450	7,500
Imperial County						
Barnes Core Drlg Co	D-10	dsl	450	Custom	450	5,500/3½"
Kern County						
B J & M Drlg Co Ltd	4	dsl	600	Natl 50	600	8,500
Barnes Core Drlg Co	D-11	dsl	225	Custom	225	3,000/3½"
Camay Drlg Co	8	dsl	850	Emsco A-800	1200	12,000
Casey & Montgomery Inc	A	dsl	900	Unit U-15	350	6,500
	D	dsl	1800	Natl 110	1800	16,000
	E	gas	1000	Natl 75	1000	10,000
Casner & Bentz	1	gas-btne	445	Emsco GA-250	195	4,500
Coastal Drlg Co	2	dsl	800	Emsco J-750	1320	11,000
	4	gas	1000	Emsco GB-800	1050	12,000
Douglas Drlg Co	1	btne	125	Emsco	125	2,500
Drlg & Prod Co	1	dsl	325	Crdwll	420	6,000
	2	dsl-gas-gaso	325	Crdwll O	432	6,000
Enterprise Oil Co	3	dsl	300	Wlsn Torcair	150	4,000/3"
Green & Dreblow Drlg Co	2	dsl	600	Wlsn Giant	600	8,500
John S Hagestad Drlg Co	2	dsl	540	Ideco H30-D	340	4,500
	3	dsl	625	Emsco GB-350	400	7,000
	4	dsl	680	Ideco H-525	440	7,500
Clyde Hall Drlg Co Inc	5	gas-btne	1000	Emsco GB-800	1000	12,000
Ivy Drlg Co	1	dsl	185	Hopper IG	185	1,500
	2	btne	185	Hopper GF	185	3,000
K L Kellogg & Sons	25	dsl	1480	Natl 75	1480	9,500
	28	dsl	1350	Natl 100	1100	13,000
	31	gas	1580	Natl 125	1050	16,000
Knight Drlg Co	1	dsl	1020	Unit U-35D	500	8,000
Miller & York	G	dsl	275	Emsco G-36	275	5,000
	H	dsl	275	Emsco GA-250	275	5,000
	J-11	dsl	210	Hopper GTA	210	3,500
	12	dsl	300	Hopper M	380	6,000
Newton Drlg Co	1	dsl	300	Ideco H-30	—	4,000
Rocky Mountain Drlg Co	10	dsl	1200	Emsco J-1000	1550	15,000
	13	gas	1200	Emsco J-1250	1500	20,000
Santa Maria Drlg Co	3	gas	850	Wlsn Titan	1200	10,000
Swett Bros Drlg Co	1	prop	250	Hopper	200	3,500
	2	prop	150	Crdwll	150	2,000
Rusty Walters Drlg Co	1	dsl	300	Cooper D-50	300	6,500/4"
Kings County						
Armstrong Fowler Inc	2	dsl	200	Natl T-12	250	2,500
Miller & York	A	dsl	825	Emsco GC-500	825	10,000
	C	dsl	550	Emsco GB-350	425	6,500
Newton Drlg Co	4-40	dsl	320	Emsco GB-250	—	6,000
Los Angeles County						
Camay Drlg Co	2	gas	1080	Wlsn Titan	1000	12,000
	5	gas	535	Natl 50	500	7,000
	6	gas	605	Natl 50	500	7,000
	7	gas	535	Emsco G-300	300	6,000
Drlg & Expl Co of Delaware Inc	20	gas-gaso	1200	Natl 100	900	13,500
Enterprise Oil Co	4	dsl-LPG	300	Howard-Turner	220	2,800
F E Gober Drlg Co	2	gas	816	Natl 50A	450	7,500
International Drlg Co	1	gas	770	Natl 50	450	6,500
Fred Johnson Drlg Co	1	gas-gaso	1050	Emsco J-1000	1050	12,000
	2	gas-gaso	1750	Wlsn Titan	1050	10,000
	3	gas-gaso	700	Natl 50	700	6,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Kee & Simpson Drlg Co	1	gas-btne	—	Natl 50	380	6,500
	2	gas-btne	—	Beth 58	420	7,000
K L Kellogg & Sons	18	gas	925	Natl 50	650	7,000
	23	gas	2090	Natl 75	790	9,500
Macrate Prod Co	2	dsl	175	Ideco HD-30	190	3,500
	7	gas	300	Wgnr Mrhse	250	4,000
Rocket Drlg Co	1	gas-btne-prop	555	Emsco G-300	350	4,500
Rocky Mountain Drlg Co	7	gas	1200	Natl 100	1110	15,000
Santa Fe Drlg Co	3	gas	900	Emsco G-500	440	7,500
	23	dsl	600	Ideco H-40	300	6,000
	28	gas	1200	Natl 80-B	1350	12,000
Santa Maria Drlg Corp	1	gas	850	Wisn Titan	1200	10,000
The Sun Drlg Co	3	elec	750	Natl 110	1100	15,000
	4	elec	1000	Natl 110	1100	15,000
Terminal Drlg & Prod Co	1	gas	—	Natl 50	440	7,000
	3	dsl	—	Wisn Mogul	350	5,000
	4	gas	—	Ideco H-40	460	6,000
	5	dsl	—	Ideco H-40	350	5,000
	14	gas	—	Ideco H-25	105	2,000
Orange County						
K L Kellogg & Sons	19	dsl	1200	Natl 75	790	9,500
Santa Fe Drlg Co	25	gas	1350	Natl 55	900	10,000
Terminal Drlg & Prod Co	2	dsl	—	Natl 50A	700	8,500
San Benito County						
Miller & York	1	dsl	275	Frnks Clipper	225	3,500
Newton Drlg Co	2	dsl	320	Ideco H-40	—	5,000
San Luis Obispo County						
K L Kellogg & Sons	33	gas	1750	Emsco GB-800	1050	12,000
Santa Maria Drlg Corp	5	gas	750	Wisn Atlas	900	10,000
Santa Barbara County						
B J & M Drlg Co Ltd	3	gas	450	Natl 50	775	8,500
Casner & Bentz	2	gas-btne	800	Emsco GA-450	550	8,000
Santa Maria Drlg Corp	4	gas	500	Wisn Giant	900	7,500
Tulare County						
Myers Drlg Serv	9	dsl	165	Crdwll	165	3,000/3½"
Ventura County						
Camay Drlg Co	3	gas	855	Natl 75	650	9,000
	4	gas	555	Emsco 500	500	7,500
	9	gas	1900	Natl 130	1900	16,000
Casey & Montgomery Inc	B	gas	1000	Natl 75	1000	10,000
	C	dsl	1000	Natl 50	700	8,500
Drlg & Expl Co of Delaware Inc	28	gas-gaso	800	Natl 50A	750	10,000
	29	gas-gaso	1500	Natl 34-10	1200	18,000
	31	gas-gaso	1500	Natl 130	1200	18,000
Hayes & Sprague Inc	2	dsl	1950	Natl 125	1950	16,000
International Drlg Co	5	gas	1050	Wisn Titan	1050	12,000
	6	dsl	1040	Wisn Spr Titan	780	12,000
K L Kellogg & Sons	7	gas	2240	Natl 100	1050	13,000
	27	gas	2000	Natl 100	1050	13,000
	29	gas	1370	Natl 75	700	9,500
	32	gas	1400	Natl 75	1050	9,500
	34	gas	2475	Natl 125	2475	16,000
	35	dsl	1800	Natl 130	1800	18,000
	36	gas	2475	Natl 125	2475	16,000
Rocky Mountain Drlg Co	1	gas	1200	Natl 75	900	11,000
	2	gas	1200	Natl 75	900	11,000
	3	gas	1200	Natl 100	900	14,000
	4	gas	1400	"Oilwell" 96	1750	20,000
	5	gas	1480	"Oilwell" 96	1850	20,000
	6	gas	1200	Emsco J-1000	1550	15,000
	8	gas	1400	Natl 125	1750	20,000
	9	gas	1200	Natl 125	1500	20,000
	12	gas	1480	Natl 125	1850	20,000
	15	gas	1200	Emsco J-750	900	11,000
A D Rushing Inc	1	dsl	—	Natl 40	875	4,800
	2	dsl	—	Ideco 7-11	1610	12,000
	3	gas	—	Natl 50	1075	7,500
	4	gas	—	Wisn Trair Gnt	1700	9,000
	5	gas	—	Natl 50	1075	7,500
Santa Fe Drlg Co	9	gas	1050	Wisn Titan	900	10,000
	11	dsl	300	Wgnr-Mrhse	300	6,000
	26	gas	1200	Wisn Titan	900	10,000
Santa Maria Drlg Corp	2	gas	400	Wisn Giant	600	5,000
The Sun Drlg Co	1	dsl	950	Natl 110	1425	15,000
	2	gas	1400	Natl 125	1250	15,000
	5	gas	1850	Natl 110	1500	15,000
Terminal Drlg & Prod Co	6	dsl	—	Emsco GC-500	440	7,000
	17	dsl	—	Wisn Mogul	350	5,000
	18	dsl	—	Ideco H-525	540	8,000
United Drlg Co	1	gas	380	Emsco EDA	450	6,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
COLORADO						
Baca County						
Herndon Drlg Co	3	gas	600	Natl 50	750	8,000
Holm Drlg Co	4	dsl	560	Wisn Giant	300	5,500
Boulder County						
Exeter Drlg Co	1	dsl	325	Emsco GA-350	425	7,000
Dolores County						
Kerr-McGee Oil Ind Inc	1	gas	825	Unit U-15	832	10,000
Grand County						
B F Allison Drlg Co	2	gas-btne	675	Unit U-15	675	8,500
Falcon Seaboard Drlg Co	MA-1	gas-btne	300	Unit U-35	210	6,500
Jefferson County						
Taylor Expl Co Inc	2	gaso	—	Failing	—	1,500
	6	btne	—	Failing	—	1,200
Kiowa County						
Branyan Drlg Co	2	dsl	700	Beth	700	9,000
La Plata County						
Anschutz Oil Co Inc	4	gas	800	Wisn Giant	700	8,500
Arapahoe Drlg Co	1	gas-btne	300	Natl T-32	320	6,000
Exploration Drlg Co	10	gas	505	Unit U-15	400	8,000
Great Western Drlg Co	20	dsl	265	Frnks SAL-1600	600	5,000
Urice Drlg Co	1	gas-btne	700	Emsco GA-500	700	8,500
Larimer County						
Mountain States Drlg Co Inc	17	dsl	540	Natl T-32	—	6,000
Logan County						
Don Johnston Drlg Co	1	dsl	270	Natl T-12	195	5,000
Strain Drlg Co	2	dsl	400	Unit U-15	550	7,500
Mesa County						
Carmack Drlg Co	5	gas	400	Natl T-32	320	6,000
Willard Pease Drlg Co	1	dsl	340	Stratmaster 90	320	5,500/3½"
Moffat County						
Rowan Drlg Co Inc	24	gas-btne	504	Natl 50	1077	8,500
Montezuma County						
Great Western Drlg Co Inc	23	dsl	500	Unit U-15	800	7,500
Don Johnston Drlg Co	3	gas-btne	650	Natl 50	650	7,500
Nye & Snell Drlg Co	1	gas	375	"Oilwell" 66	550	6,000
Morgan County						
Exeter Drlg Co	2	btne	320	Emsco GA-250	250	6,000/4"
Garvey Drlg Co	19	dsl	300	Wisn Roadair	450	7,000/3½"
Rio Blanco County						
A O Bullock Drlg Co	3	gas	370	Beth Twister	—	7,500
Carpenter-Trant Drlg Co	1	btne	185	Crdwll RL	185	3,000
Delta Drlg Co	25	gas-btne	1520	Emsco J-1250	1250	15,000
George Noland Drlg Co Inc	8	gas-btne	—	Emsco GA-500	730	8,500
Routt County						
Carmack Drlg Co	1	dsl	680	Natl 50-A	850	8,000
Washington County						
B F Allison Drlg Co	1	gas-btne	450	Natl T-32	400	5,500
Brinkerhoff Drlg Co	10	dsl	375	Natl T-32	375	6,000
	11	dsl	275	Natl T-20	275	5,500
Garvey Drlg Co	12	dsl	300	Wisn Giant	320	6,000/3½"
Weld County						
B F Allison Drlg Co	4	gas-btne	900	Brwstr N-75	900	11,000
	5	gas-btne	450	Frnks 137	390	5,500
Herndon Drlg Co	8	gas	600	Natl 50-A	750	10,500
Lewis Bros Inc	1	dsl	376	Crdwll J-450	476	7,500
Nebraska Drlrs Inc	1	dsl	300	Unit U-15	530	7,500
Don M Rounds Drlg Co Inc	2	dsl	900	Crdwll O	900	9,000
FLORIDA						
Palm Beach County						
Dorris Ballew Inc	3	dsl	760	Wisn Titan	1900	15,000
ILLINOIS						
Christian County						
LaMac Oil Co	1	dsl	—	Wisn Giant	600	4,700
Joe Simpkins	1	dsl	—	Emsco GA-160-T	500	3,500
	3	dsl	500	Natl T-20	500	5,000
V S & S Drlg Co	2	dsl	—	Wisn	—	2,400
Clark County						
W L Dillier	2	gas	—	Failing 2500	130	2,000
Clay County						
Woody Jones Drlg Co	1	dsl	240	Unit U-34	230	4,500
Shulman Bros	1	dsl	330	Crdwll S-350	—	5,500
Don Slape Drlg Co	3	dsl	260	"Oilwell" 64-B	230	5,500
Clinton County						
Conrey Drlg Co	1	gas	140	Wisn Super	140	2,000/3½"
M Mazzarino	—	gas-gaso	200	Frnks 2000	200	2,500
Perrine & Perrine Drlg Contr	1	btne	—	Crdwll S	185	6,000
Troop Drlg Co	1	gas-gaso	—	Natl T-20	200	4,500
Coles County						
D B Lesh Drlg Co	3	dsl	200	Natl T-20	200	4,000
U & E Drlg Co	—	dsl	400	Crdwll S	200	3,500

Announcing IDECO AS EXCLUSIVE KELCO *Export* REPRESENTATIVE

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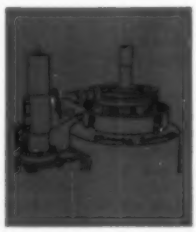
The safety keynote featured in all KelCo products has developed outstanding acceptability over almost two decades of world-wide operation. KelCo catheads, with exclusive anti-fouling devices, wide interchangeability of parts and choice of controls, are available for every size rig. Write today for complete details.



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AIR OPERATED POWER SLIPS—Easily serviced. Patented automatic safety latch operates with each lift of the slips. Available in sizes to accommodate 2" tubing to 7" casing. **FULGRIP TUBING TONGS**—Light-strong Chrome-moly steel tongs. Full contact diamond-cut dies will not score tubing. Sizes for 2⅜" to 4½" tubing.

IDECO Inc. D1
P. O. Box 1331 Dallas 21, Texas

KELCO *"the first modern cathead"*

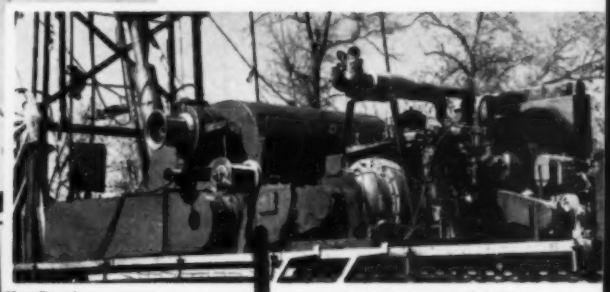
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Edwards County						
Herndon Drlg Co	5	gas	375	Brwstr N-4	375	4,500
Effingham County						
Claypool Drlg Co	1	btne	225	Natl T-20	185	4,500
Fayette County						
C R Winn Drlg Contr	1	dsl	135	Wisn Super	135	3,000
Franklin County						
E F Moran Inc	1	btne	300	Brwstr N-4	600	6,000
Gallatin County						
V S & S Drlg Co	4	dsl	—	Beth	—	4,200
Hamilton County						
C E Brehn	2	dsl	240	Brwstr N-45	—	7,000
Kendall-Davis Drlg Co Inc	1	dsl	300	Wisn Mogul	300	4,000
E F Moran Inc	2	btne	300	Natl T-12	300	4,500
Walter W Willis	1	dsl	278	Beth 430S	200	4,500
Jasper County						
W L Dillier	3	gas	—	Failing 2500	130	2,000
J W Rudy	1	dsl	150	Natl T-20	185	5,000
	50	dsl	250	Natl 50	214	6,000
Don Slape Drlg Co	2	dsl	240	Unit U-34	230	4,500
Jefferson County						
Ted Lindsay	1	dsl	220	Crdwll S	160	4,500
Petro Drlg Co Inc	1	dsl	450	Brwstr N-4	300	6,500
La Salle County						
D B Lesh Drlg Co	1	dsl	200	Natl T-20	200	4,000
Lawrence County						
Walton Drlg Co	1	gas	—	Failing 2500	—	2,000/3½"
	2	gas	—	Failing 2500	—	2,000/3½"
Walter W Willis	2	dsl	256	Natl T-12	237	4,500
Marion County						
Claypool Drlg Co	2	btne	185	Natl T-12	185	4,500
Conrey Drlg Co	2	dsl	175	Wisn Super	175	2,500/3½"
Graham Powell	1	dsl	—	Natl 50	—	6,000
	2	dsl	—	Natl T-12	—	3,200
C R Winn Drlg Contr	2	dsl	225	Crdwll L	225	4,000/3½"
Richland County						
W L Dillier	1	gas	—	Natl T-12	212	3,000
	4	gas	—	Failing 2500	130	2,000
U & E Drlg Co	—	dsl	500	Frnks 4500	400	5,000
St. Clair County						
Henry Gwaltney Drlg Co	3	gas	100	—	100	1,500
Saline County						
C E Brehn	1	dsl	240	Brwstr N-45	—	7,000
Eakle & Holder Drlg Co	1	dsl	300	Brwstr N-4	200	5,500
Paco Petroleum Corp	1	dsl	320	Natl T-32	320	6,000
Don Slape Drlg Co	5	btne	360	Natl T-12	260	4,500
Wabash County						
Bury Drlg Co	1	dsl	265	Crdwll RL	250	3,000
	2	dsl	265	Crdwll RL	250	3,000
Wayne County						
Calvert Drlg Inc	11	dsl	260	Natl T-32	190	5,000
Central Drlg Co	1	gas	225	Natl 40	185	4,500
Central Drlg Co (Fairfield Ill)	6	btne	260	—	—	4,000
D B Lesh Drlg Co	4	gas	450	Natl 50	450	7,000
Ted Lindsay	2	dsl	220	Natl T-16	220	5,000
Paco Petroleum Corp	3	dsl	320	Unit U-35	320	7,000
Don Slape Drlg Co	4	dsl	300	Brwstr N-4	245	4,500
White County						
Calvert Drlg Inc	12	dsl	260	Ideco H-30	260	4,500
	16	dsl	260	Ideco H-35	190	5,000
Central Drlg Co	1	dsl	225	Unit U-34	225	4,000
Central Drlg Co (Fairfield Ill)	4	dsl	—	—	—	4,000
Eakle & Holder Drlg Co	3	dsl	300	Ideco H-30	300	5,500
Ferbanta Drlg Co	1	gas	250	Crdwll S-140	200	4,500
General Geophysical Co	27	dsl	—	—	400	4,500
Harris Drlg Co	2	btne	276	Natl 40	172	4,000
	3	dsl	285	Natl 50	285	8,500
Herndon Drlg Co	7	gas	409	Natl T-32	559	4,500
	9	gas	240	Natl T-25	390	4,000
Ted Lindsay	3	dsl	160	Ideco H-30	160	4,000
Lohmann-Johnson Drlg Co Inc	7	gas	300	Crdwll S	440	4,500
Gene Miller Inc	5	dsl	300	Brwstr N-4	—	4,500
E F Moran Inc	3	btne	300	Crdwll S	300	4,000
Don Slape Drlg Co	1	dsl	260	"Oilwell" 64-A	230	5,000
Williamson County						
Calvert Drlg Inc	8	dsl	260	Ideco H-30	190	4,500
INDIANA						
Gibson County						
Harris Drlg Co	1	btne	195	Crdwll S	172	4,000
Highland Oil	2	—	—	B Erie 28L	—	2,000
The Noah Petroleum Co	1	dsl	300	Brwstr N-4	300	5,500
Paco Petroleum Corp	2	btne	200	Wisn Mogul	165	4,000
T & H Corp	1	dsl	225	Crdwll L	225	3,500
Grant County						
Calvert Drlg Inc	21	dsl	350	Ideco H-35	260	6,500/4"
Jennings County						
Gordon Drlg Co	12	dsl	600	Wisn Giant	550	10,000
Pike County						
Henry Gwaltney Drlg Co	1	dsl	200	Natl T-12	165	3,000
Posey County						
E F Moran Inc	4	btne	300	Brwstr N 3	300	3,500/3½"
South State Drlg Corp	1	dsl	100	Crdwll	110	3,100/2⅛"
IOWA						
Dallas County						
Kirby Oil Ind	—	gas-gaso	400	Mayhew 3000	145	3,000
	—	dsl	400	Brwstr N-4	400	4,500
	—	dsl	300	Unit U-34	275	4,500
KANSAS						
Barber County						
Beardmore Drlg Co	1	dsl	300	Natl 50	450	6,000
Brack Drlg Co Inc	2	dsl	325	Unit	—	6,000
	5	dsl	—	—	254	5,500
D & M Drlg Co Inc	2	gas-btne	225	Brwstr N-4	280	5,000
Graham-Michaelis Drlg Co	6	dsl	175	Beth Breeze	175	4,000
Iron Drlg Co	6	dsl	240	Emsco GA-250	268	5,000
Patton Drlg Co Inc	1	gas	—	Natl 50	450	6,500
	2	dsl	—	Natl 50	350	5,500
Prime Drlg Co	5	dsl	300	Natl T-20	300	5,000
Barton County						
Anschutz Oil Co Inc	1	dsl	300	Wisn Giant	280	5,000
Garvey Drlg Co	8	dsl	175	Wisn Giant	296	5,000
Harms-Burt Drlg Co	2	dsl	160	Emsco 350	350	6,500
A L Jackson Drlg Co	1	dsl	285	Unit U-15	285	6,000
Reserve Drlg Co Inc (Kans)	3	dsl	320	Natl T-32	320	5,500
Butler County						
Rex & Morris Drlg Co	1	dsl	260	Natl T-25	260	4,000
Comanche County						
Capitt Drlg Inc	3	dsl	525	Beth C-50	500	8,500
Cowley County						
Criswell Drlg Co	1	dsl	300	Unit U-34	300	4,500
Elk County						
R L Horn & Sons Drlg Co	1	dsl	185	Frnks Comet	300	5,500
	2	dsl	185	Frnks Sr Clpr	185	4,000
Ellis County						
K & E Drlg Inc	1	dsl	285	"Oilwell" T-52	—	6,000
Mallonee Drlg Co Inc	1	btne	220	Beth Breeze	200	4,500
Ellsworth County						
Buick Drlg Inc	2	dsl	300	Wilson	—	4,500
Shelley-Miller Drlg Co	1	dsl	—	Wilson	—	5,500
Graham County						
Empire Drlg Co (Kans)	1	dsl	300	Natl T-32	300	5,000
Garvey Drlg Co	3	dsl	175	Unit U-15	296	5,000
	11	dsl	175	Wisn Giant	296	5,000
Herndon Drlg Co	10	gas	409	"Oilwell" 64-A	559	4,500
K & E Drlg Inc	2	dsl	285	Natl T-20	—	5,000
Lohmann-Johnson Drlg Co Inc	3	gas	300	Natl 50	450	5,500
Powell Drlg Co	1	dsl	—	Emsco GB-350	350	6,500
Prime Drlg Co	3	dsl	275	Unit U-34	285	4,500
Veeder Supply & Dev Co	D	dsl	280	Natl T-25	300	4,500
Greenwood County						
Greenwood Petroleum Mgmt Inc	1	dsl	—	Frnks 5000	—	—
Harper County						
Harry Bass Drlg Co	114	gas	570	Crdwll	570	7,000
Prime Drlg Co	2	dsl	300	Beth S-45	300	5,000
Walters Drlg Co	1	gas	—	Natl 50	500	5,500
Haskell County						
R W Rine Drlg Co	1	gas-btne	620	Unit U-15	600	7,500
Hodgeman County						
Graham-Michaelis Drlg Co	1	dsl	275	Beth Twister	500	6,500
	8	dsl	400	Crdwll D	400	5,000
Kingman County						
Garvey Drlg Co	5	dsl	175	Unit U-15	296	5,000
	10	dsl	175	Wisn Giant	296	5,000
Herndon Drlg Co	1	gas	409	"Oilwell" 64-B	559	6,000
Kiowa County						
Falcon Seaboard Drlg Co	20	gas-btne	425	Unit U-15	425	8,500
	26	dsl	225	Beth Twstr	212	6,500
	27	gas-btne	185	Unit U-34	210	5,000
Garvey Drlg Co	22	dsl	300	Wisn Mogul 42	450	6,000
Lewis Drlg Co	2	dsl	550	Unit U-15	550	7,500
Transit Corp	3	dsl	280	Emsco	—	4,500
Lane County						
Gabbert-Jones Drlg Co	3	gas	320	Emsco 300	300	5,000
Lincoln County						
Donald T Ingling	4	dsl	225	Brwstr N-4	225	5,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
McPherson County						
Mallard Drlg Co	1	dsl	285	Emsco G-300	285	4,000
Veeder Supply & Dev Co	E	dsl	270	Frnks 658	270	3,500
Meade County						
D & M Drlg Co Inc	1	gas-btne	550	Natl 50	550	7,500
	3	dsl	600	Unit U-15	600	7,500
Falcon Seaboard Drlg Co	16	gas-btne	425	Unit U-15	425	8,500
Graham-Michaelis Drlg Co	3	dsl	300	Crdwll S	175	5,000
	4	dsl	500	Unit U-15	500	7,000
	10	dsl	600	Unit U-15	600	9,000
Midwestern Drillers Inc	2	dsl	320	Unit U-15	600	7,500
Moran Bros Inc	11	dsl	300	Wlsn Giant	350	5,000
Morton County						
Garvey Drlg Co	18	dsl	300	Wlsn Roadair	450	6,000
Graham-Michaelis Drlg Co	5	dsl	275	Crdwll E	275	4,000
Lewis Drlg Co	1	dsl	260	Crdwll	300	6,000
Reno County						
Pickrell Drlg Co	1	dsl	450	Unit U-15	450	6,500
Rice County						
Bennett & Roberts Drlg Co	3	dsl	250	Emsco 250	250	5,000
Harms-Burt Drlg Co	1	dsl	150	Emsco 250	250	5,000
Rupp-Ferguson Oil Co	1	dsl	350	Ideco H-35	350	5,000
Rooks County						
Garvey Drlg Co	14	dsl	175	Wlsn Giant	296	5,000
Iron Drlg Co	7	dsl	268	Emsco GB-160	236	4,500
Transit Corp	2	dsl	280	Emsco	—	4,500
	4	dsl	280	Emsco	212	4,500
Rush County						
Bennett & Roberts Drlg Co	1	dsl	250	Emsco 250	250	5,000
Russell County						
Shields Drlg Co Inc	2	dsl	300	Beth C-50	300	8,000
Saline County						
Greenland Drlg Co	1	dsl	190	Emsco 160	190	4,500
Sedgewick County						
Gabbert-Jones Drlg Co	1	gas	320	Emsco 300	300	5,000
Peak Drlg Co Inc	12	gas-LPG	220	Natl T-12	220	4,000
	14	gas-LPG	200	Brwstr N-35	200	4,000
Seward County						
Bennett & Roberts Drlg Co	2	dsl	250	Emsco 250	250	6,000/3½"
Moran Bros Inc	14	dsl	275	Natl T-12	300	4,500
Stafford County						
Garvey Drlg Co	15	dsl	175	Wlsn Giant	296	5,000
Lewis Drlg Co	3	dsl	260	Crdwll	260	5,500
Shields Drlg Co Inc	3	dsl	300	Wlsn Giant	400	6,000
Sumner County						
Beardmore Drlg Co	2	dsl	300	Emsco 300	320	4,000
Capitt Drlg Inc	2	dsl	300	Beth S-45	285	5,000
Herndon Drlg Co	6	gas	409	Natl T-32	559	6,000
Wichita County						
C K C Drlg Co	1	btne	110	Joy	110	1,500/2⅛"
KENTUCKY						
Daviess County						
Henry Gwaltney Drlg Co	2	gas-prop	260	Crdwll	165	3,000
Hupp & Hume	2	dsl	165	Natl 40	300	3,000
Hopkins County						
Stouder Drlg Co	2	LPG	200	Natl T-12	160	4,000
McLean County						
Stouder Drlg Co	1	LPG	200	Natl 40	160	4,500
Muhlenberg County						
Hupp & Hume	1	dsl	255	Natl 40	300	4,500
Union County						
Big Seven Drlg Co	1	dsl	300	Emsco GB	300	4,500
Webster County						
Kendall-Davis Drlg Co Inc	2	dsl	300	Crdwll S	300	4,000
Lohmann-Johnson Drlg Co Inc	6	gas	300	Crdwll S	440	4,500
Shulman Bros	2	dsl	330	Crdwll L	—	3,500
Temple Drlg Co Inc	2	dsl	300	Crdwll S	440	4,500
V-T Drlg Co	1	dsl	220	Crdwll H	160	4,000
LOUISIANA						
Acadia Parish						
Falcon Seaboard Drlg Co	2	stm	1200+	Ideco Giant	—	25,000
	11	stm	1000+	Alco BIW 12	—	17,000
Glasscock-Wilson Inc	8	gas	1600	Natl 110	1200	15,000
Grey Wolf Drlg Co	2	dsl-elec	1250	Alco BIW 12	1250	15,000
Lamar Drlg Corp	1	gas	420	Unit U-15	—	7,500
Nicklos Drlg Co	10	stm		Natl		17,000
Owen Drlg Co	4	stm	1000+	Emsco UBLS-54	—	14,000
	9	stm	740	Ideco Gig Gnt	540	16,000
Sunnyland Contr Co Inc	9	dsl	—	Crdwll D	450	8,000

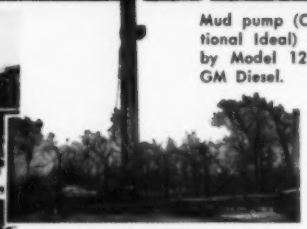
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Allen Parish						
Crawford Drlg Co	1	dsl	695	Brwstr N-7	500	9,000
Glasscock-Wilson Inc	10	gas	1050	Natl 55	800	10,500
Lake Charles Drlg Inc	3	gas-btne	345	Beth S-45E	290	8,600/3½"
Owen Drlg Co	6	gas	555	Unit U-15	—	8,000
Penrod Drlg Co	23	dsl			730	9,000
	26	gas			730	9,000
Ascension Parish						
Dorris Ballew Inc	1	dsl	760	Wlsn Titan	1300	12,500
M M Lindsey Drlg Co	2	gas	290	Natl T-32	—	6,000
Assumption Parish						
Gracey-Hellums Corp	Bge 2	stm	1200	Natl 23-9FE	1200	15,000
W P Taylor Drlg Co	1	gas	—	Emsco	1000	13,000
Beauregard Parish						
Penrod Drlg Co	22	dsl	—	—	600	9,000
The Power Rig Drlg Co	4	gas-btne	700	Unit U-15	—	10,000
Bienville Parish						
A W Eggleston Inc	3	dsl	900	Ideco PR-1050	900	14,000
Bossier Parish						
B-M Drlg Co Inc	2	gas	685	Emsco GB-350	500	8,000
Barnwell Drlg Co Inc	4	gas	500	Wlsn Giant	185	5,000
Milton Crow Inc	3	gas	600	Brwstr N-7	400	7,500
Penrod Drlg Co	16	gas-btne	—	—	1500	15,000
Caddo Parish						
W C Allen Drlg Co	1	gas-btne	145	Wlsn Super	78	3,000/3½"
	2	gas-btne	145	Wlsn Super	78	3,000/3½"
Dudley C Beene Inc	1	gas	145	Brwstr N-2	145	2,500
Burnham & Robinson Drlg Co	1	dsl	350	Brwstr N-5	350	7,000
Crow Drlg & Prod Co	17	dsl	650	Brwstr CR-48T	650	7,500
Milton Crow Inc	5	gas	600	Brwstr N-7	400	7,500
B F Edington Drlg Co Inc	102	gas-gaso	120	Failing	180	1,500/2⅛"
	103	gas-gaso	150	Hacker	200	2,000/2⅛"
Gary Drlg Co	1	btne	90	—	90	2,000
	2	btne	145	—	200	4,000
F E Hargraves & Sons Drlg Co	2	btne	185	Brwstr W-50	185	2,800/3½"
	3	btne	185	Brwstr W-50	185	2,800/3½"
Johnson Drlg & Serv Co	2	dsl	225	Beth Twister	300	6,500
Kendrick Bros	2	gas-btne	185	Brwstr N-4	185	5,000
Penrod Drlg Co	3	dsl	—	—	730	9,000
Tex-Mex Drlg Co	11	stm	—	—	1000+	12,000
Wheless Drlg Co	13	gas-btne	700	Emsco J-750	750	10,500
Calcasieu Parish						
Delta Drlg Co	11	stm	1000	Emsco UBLS-54	1690	15,000
A W Eggleston Inc	2	gas-btne	500	Ideco M-10000	627	9,500
M M Lindsey Drlg Co	1	gas	380	Brwstr N-55	—	7,500
Mac Drlg Co	11	stm	800+	Natl 23-9F-ED	1000+	20,000
Owen Drlg Co	3	gas	900	Ideco M-1000	—	12,500
Cameron Parish						
Delta Drlg Co	20	gas-btne	1520	Emsco J-1250	1250	15,000
	38	stm	530	Natl 239-S	1135	12,000
Harry L Edwards Drlg Co	6	stm	1000+	Natl 23-9S	1000+	15,000
Glasscock-Wilson Inc	12	gas	1300	Natl 110	1200	15,000
Grey Wolf Drlg Co	1	gas-btne	945	Emsco GB-800	—	12,500
Win Hawkins Drlg Co	1	stm	—	Alco BIW 14	—	15,000
	3	stm	—	Emsco UBLS-54	—	14,000
Penrod Drlg Co	4	gas-btne	—	—	1425	15,000
The Power Rig Drlg Co	3	gas-btne	1000	Ideco 800	—	12,000
Prince Marine Drlg & Exp Co	1	dsl	1500	"Oilwell" 96	1500	15,000
Carnes W Weaver Drlg Co	2	gas-btne	900	Ideco	—	11,000
C B Webster Drlg Co	6	stm	1100	Emsco ECA-10½	1200+	15,000
Wheless Drlg Co	Bge 12	gas-btne	1200	Natl 80	800	12,000
Catahoula Parish						
Dorris Ballew Inc	6	dsl	380	Unit U-15	600	7,500
Scooter's Drlg Serv	2	dsl	300	Brwstr N-4	300	4,500
Claiborne Parish						
Barnwell Drlg Co Inc	34	dsl	800	Unit U-34	380	7,000
Drlg & Expl Co of Delaware Inc	32	stm	1400	Emsco ECA	—	15,000
	36	stm	1400	Natl 34-8	—	15,000
Maritzky & Bibby	1	gas	330	Brwstr	185	5,000
McCalman Drlg Co Inc	1	dsl	—	Brwstr N-4	300	5,500
Penrod Drlg Co	36	stm	—	—	—	14,000
Wheless Drlg Co	1	gas-btne	600	Brwstr N-45	600	7,500
	2	gas-btne	600	Wlsn Atlas	700	8,500
	3	gas-btne	600	Emsco GB-350	600	7,500
	5	stm	900	Emsco UBLS-54	1000+	11,000
	Bge 10	gas-btne	900	Brwstr N-7	700	9,500
Concordia Parish						
Crow Drlg & Prod Co	19	dsl	325	Brwstr C-5	325	7,000/3½"
De Sota Parish						
Dudley C Beene Inc	2	dsl	285	Brwstr N-3	185	4,000
McGoldrick & Watson Drlg Co	1	btne	145	Brwstr N-3	140	3,500

DEPENDABLE POWER

Power for drawworks is provided by Model 8107 GM Diesel Engine.



Mud pump (C-150-B National Ideal) is powered by Model 12103 Model GM Diesel.



Johnson Drilling Company Truck-mounted portable rig in the Tyler area.

"OPERATED MORE THAN TWO YEARS WITH NO MAJOR REPAIRS."

That's how T. J. Johnson of Tyler, Texas, head of the Johnson Drilling Company, describes the new application of GM Diesel engines that powers the hard-working portable rig shown above. A Model 8107 GM Diesel Engine provides power for the Spencer-Harris Drawworks and a Model 12103 GM Diesel Engine operates the mud pump. This well, in the Tyler area, was drilled to 6300 feet with 3½-inch drill pipe and eight drill collars.

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Performance — "Superior."

Dependability — "Engines are ready to deliver at any time called upon."

Power — "The two-cycle system gives fast, positive power at all times."

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THE WORLD'S LARGEST DISTRIBUTOR OF DIESEL ENGINES

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Franklin Parish						
Scooter's Drlg Serv	4	dsl	300	Wisn Giant	300	4,500
Thrasher Drlg Co Inc	1	gas-btne	350	Unit U-15	600	8,500
Iberia Parish						
Clegg & Hunt	8	dsl	—	—	1275	18,000
Harry L Edwards Drlg Co	4	stm	1000+	Alco BIW 12	1000+	15,000
A W Eggleston Inc	1	gas-btne	560	Natl Ideal 60	560	9,800
Golden Meadow Well Serv	6	dsl	1450	Beth 1013	—	15,000
Kilroy Drlg Co	1	gas	600	"Oilwell" 96	1400	15,000
Rowan Drlg Co Inc	Bge 26	dsl	1325	Natl 100	1545	14,000
Shoreline Drlg Co Inc	8	dsl	1650	Unit U-40	1650	12,000
C B Webster Drlg Co	3	gas	900	Emsco J-1250	1300	15,000
Wheless Drlg Co	Bge 6	gas-btne	1000	Wisn Titan	1000	12,000
Ibarville Parish						
Delta Drlg Co	31	gas-btne	1020	Emsco J-1000	1260	13,000
Glasscock-Wilson Inc	9	gas	1200	Natl 80-B	800	12,500
Hawkins-Wilkins Prod Co	1	stm	—	Natl 3410FE	—	15,000
Win Hawkins Drlg Co	4	stm	—	Natl 3410FE	—	15,000
Jefferson Parish						
Delta Drlg Co	16	dsl	1200	Beth MC-950	1400	15,000
	35	gas-btne	1200	Emsco J-1100	1200	15,000
	37	dsl	900	Beth MC-950	1400	15,000
Glasscock-Wilson Inc	11	gas	1050	Natl 55	800	10,500
Grey Wolf Drlg Co	4	gas-btne	585	Emsco GB-500	—	9,500
Sunnyland Contr Co Inc	3	stm	—	Emsco ECB	724	16,000
Jefferson Davis Parish						
Bullard Drlg Co Inc	1	stm	1000+	Natl 34-10FE	1000+	16,000
Circle Drlg Co Inc	2	gas-btne	800	Brwstr N-75	900	11,000
	4	gas-btne	800	Brwstr N-75	960	11,000
Clegg & Hunt	1	stm	—	Emsco I0	—	15,000
Delta Drlg Co	21	gas-btne	800	Natl 75	650	9,500
Harry L Edwards Drlg Co	5	stm	1000+	Natl 23-10½FE	1000+	16,000
	7	stm	1000+	Alco BIW 12	1000+	15,000
Mac Drlg Co	3	stm	600	Natl 23-9-FE	1000+	20,000
Nicklos Drlg Co	14	gas-btne	—	Natl 75	1000	12,000
Owen Drlg Co	1	stm	540	Ideco Big Gnt	—	15,000
Prince Marine Drlg & Exp Co	4	gas	1600	Emsco J-1100	1400+	14,000
Rowan Drlg Co Inc	Bge 6	dsl-elec	1200	Emsco ED	2800	18,000
	Bge 14	dls-elec	1600	Emsco ECA	2325	18,000
	Bge 18	stm	1800	Emsco ED	750	18,000
Wheless Drlg Co	4	stm	1000+	Emsco UBLS-54	1000+	12,000
Lafayette Parish						
Delta Drlg Co	32	stm	1200	Ideco Big Gnt	1690	15,000
Falcon Seaboard Drlg Co	3	stm	1000+	Alco BIW 12	—	17,000
Owen Drlg Co	7	stm	1000+	Emsco	—	16,000
Lafourche Parish						
B B M Drlg Co	7	stm	—	Emsco EC-54	—	18,000
Brewster-Bartle Drlg Co Inc	2	dsl	—	"Oilwell" 96	1500	16,000
	6	dsl	—	"Oilwell" 96	1500	—
Circle Drlg Co Inc	3	gas-elec	1200	Ideco Big Gnt	2100	15,000
Clegg & Hunt	4	stm	—	Ideco Big Gnt	—	15,000
Doc Drlg Corp Blackie Drlg Co Inc Neva-Andre Drlg Corp	Bge DAN	dsl	1500	Beth 1013	1500	18,000
C G Glasscock Drlg Co	2	dsl	1200	Natl 80-B	—	12,000
Gracey-Hellums Corp	Bge 1	stm	1000	Natl 34-10FE	1200	15,000
Howell & Howell	3	gas	—	Emsco	696	15,000
	5	gas	—	Unit U-15	—	9,500
	7	stm	—	Emsco	600	15,500
	8	stm	—	Alco BIW DNT12	500	17,250
Marine Drlg Inc	1	stm	1800	Emsco ECB	1000+	15,000
	3	stm	1800	Emsco EDA	1000+	15,000
	4	dsl-elec	3000	Emsco EDA	1600	20,000
	5	stm	1800	Emsco UBL54	1000+	15,000
Nicklos Drlg Co	12	stm	—	Natl	—	17,000
Norton Drlg Co	Bge 6	dsl	1400	Emsco J-1250	1200	17,000
Penrod Drlg Co	42	dsl	—	Brwstr N-12A	—	18,000
	51	dsl-elec	—	Emsco EDES	—	20,000
The Power Rig Drlg Co	Bge 7	dsl	1200	Emsco GB-800	—	15,000
C B Webster Drlg Co	5	stm	1350	Natl FE-23-10½	1200+	15,000
Wheless Drlg Co	Bge 11	gas-btne	1200	Emsco J-1250	1250	13,500
LaSalle Parish						
Justiss-Mears Oil Co Inc	10	dsl	250	Emsco G-250	325	10,000/2⅛"
Lincoln Parish						
Crow Greyhound Drlg Co Inc	2	dsl	600	Brwstr N-45M	600	7,000
Delta Drlg Co	8	stm	750	Ideco Supr-Duty	1200	12,000
B F Edington Drlg Co Inc	104	gas-gaso	150	Joy	250	2,500/2⅛"
Johnson Drlg & Serv Co	1	dsl	200	Beth-Breeze	200	4,500
Ouachita Parish						
Delta Drlg Co	17	gas-btne	1020	Emsco J-1100	1300	15,000
H & S Drlg Co	1	gas-btne	1000	Wisn Titan	1000	12,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Plaquemines Parish						
Bateman Drlg Co	Bge 5	dsl-elec	900	Emsco EDA 54	1000	15,000
Brewster-Bartle Drlg Co Inc	9	dsl	—	"Oilwell" 96	1500	16,000
	12	dsl	—	"Oilwell" 96	1500	16,000
Clinch Drlg Co	1	dsl	—	Emsco GA-350	426	8,500
Continental Drlg Co	7	dsl	1200	Emsco GB-800	1200	14,000
Cron & Gracey Corp	2	stm	—	Natl 23-9-FEC	—	15,000
	3	dsl	—	TIW CT-5	520	8,000
Buster Gardner Drlg Co Inc	1	dsl	—	Beth M-58	—	9,500
Golden Meadow Well Serv	5	dsl	725	Beth 450	—	10,000
Win Hawkins Drlg Co	2	gas-btne	300	Unit U-15	485	9,000
Penrod Drlg Co	40	dsl	—	—	1095	12,000
	41	dsl	—	—	1000	12,000
	44	dsl-elec	—	—	1400	18,000
Prince Marine Drlg & Exp Co	2	dsl	1850	"Oilwell" 96	1500	16,000
Producers Drlg Co Inc	1	dsl	2000	Unit U-1220	2200	20 000/5"
Rebstock & Reeves Drlg Co	1	dsl	1050	Wisn Sup Titan	1425	15,000
Rowan Drlg Co Inc	Bge 1	dsl-elec	1600	Emsco EDA	2475	18,000
	Bge 21	dsl-elec	1000	Emsco ECA	1920	12,000
Salt Dome Prod Co	Bge 3	dsl	750	Natl 110	1000	12,500
Shoreline Drlg Co Inc	Bge 4	dsl	1860	Unit U-1220	1860	20,000
	Bge 5	dsl	1240	Unit U-20	1240	14,000
Southeastern Drlg Corp	21-Bge 7	dsl	1200	"Oilwell" 96	1600	18,000
C B Webster Drlg Co	Bge 9	dsl	1850	Emsco J-1400	2200	16,000
Pointe Coupee Parish						
Sunnyland Contr Co Inc	12	dsl	1120	Ideco H-525 SC	1000	10,000
Richland Parish						
Montgomery Drlg Co	3	gas-btne	225	Crdwll S	200	5,000
St. Charles Parish						
Bateman Drlg Co	Bge 6	dsl-elec	900	Emsco UBLS 54-10	1600	16,000
Reading & Bates Inc	1	gas-btne	900	Natl 100	1200	12,500
Nicklos Drlg Co	16	stm	—	Emsco	—	16,000
St. James Parish						
Carnes W Weaver Drlg Co	7	stm	—	Unit U-117B	—	14,000
Crawford Drlg Co	2	stm	—	Emsco ECA	500	15,000
St. John the Baptist Parish						
Delta Drlg Co	5	gas-btne	900	Natl 100	800	12,000
The Power Rig Drlg Co	8	gas-btne	1500	Ideco 7-11	—	15,000
St. Landry Parish						
Crow Drlg & Prod Co	5	dsl	825	Brwstr N-7	825	9,000
Douglas Drlg Co	2	gas-btne	600	Emsco GA-250T	250	5,500
Lake Charles Drlg Inc	2	gas-btne	290	Crdwll S	280	8,000/3½"
Pernie Bailey	1	gas	650	TIW CT-5	—	9,000
	2	gas	800	Unit U-40	—	11,000
St. Martin Parish						
Clegg & Hunt	6	stm	—	Natl 9-DMB	—	14,000
Falcon Seaboard Drlg Co	29	stm	1200+	Natl 3410	—	25,000
Glasscock-Wilson Inc	7	gas	1200	Natl 80-B	800	12,500
Howell & Howell	4	gas	—	Unit U-15	—	9,500
Mac Drlg Co	10	gas-btne	1000	Natl 130	1300	20,000
Norton Drlg Co	Bge 5	dsl	1200	"Oilwell" 96	1200	17,000
Southeastern Drlg Corp	20-Bge 6	dsl	1200	"Oilwell" 96	1100	16,000
Carnes W Weaver Drlg Co	3	gas-btne	700	"Oilwell"	—	10,500
St. Mary Parish						
Bilbo-Redding Drlg Co Inc	10	stm	900	Emsco UBLS-54	1000+	12,500
Bullard Drlg Co Inc	2	stm	1000+	Emsco ECB	1000+	16,000
	3	stm	1000+	Ideco Big Gnt	1000+	16,000
Circle Drlg Co Inc	Bge 6	dsl-elec	2300	Ideco E-2500	2750	20,000
Crown Rigs Inc	6	gas	900	Beth MC-450	600	10,000

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Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Delta Drlg Co	14	stm	900	Ideco Big Gnt	1690	15,000
Buster Gardner Drlg Co Inc	2	dsl	—	Beth Tornado	—	15,000
	3	dsl	—	Beth 1013	—	17,500
C G Glasscock Drlg Co	5	dsl	1060	Natl 75	—	12,000
	6	dsl	1660	Natl 110	—	16,000
B L McFarland Drlg Corp	Bge 1	dsl	700	Brwstr N-75	—	12,000
Nicklos Drlg Co	18	gas-btne	—	Natl 110	1600	17,000
Norton Drlg Co	Bge 3	stm	1200+	Natl 34-62	1500	17,000
	Bge 4	dsl	1400	Emsco J-1250	1500	17,000
Penrod Drlg Co	45	dsl	—	—	1500	20,000
Rowan Drlg Co Inc	Bge 13	dsl-elec	1700	Emsco FCA	2700	18,000
Southeastern Drlg Corp	14-Bge 1	dsl	1200	"Oilwell" 96	1600	18,000
Wheless Drlg Co	Bge 9	dsl	1300	Natl 130	1300	16,000
	Bge 14	dsl	1300	Emsco J-1400	1400	16,000
Tensas Parish						
Arrow Drlg Co	16	gas-elec	840	Emsco	—	10,000
Big Chief Drlg Co	31	gas	1545	Emsco 800	1515	13,500
Glenn Drlg Co	2	dsl	280	Unit U-15	450	8,500
Jett Drlg Co Inc	105	dsl	—	—	500	8,000
	109	gas-gaso	—	—	800	9,500
	112	dsl	1200	Brwstr 35	800	9,000
Montgomery Drlg Co	1	gas-btne	700	Emsco GA-500	600	9,500
Pyburn Drlg Co	1	dsl	500	Ideco M-750	750	9,000
	2	gas	250	Wilson	800	9,000
Terrebonne Parish						
Brewster-Bartle Drlg Co Inc	5	dsl	—	"Oilwell" 96	1500	16,000
	7	dsl	—	"Oilwell" 96	1500	16,000
	8	dsl	—	"Oilwell" 96	1500	16,000
	11	dsl	—	"Oilwell" 96	1500	16,000
Clegg & Hunt	11	dsl-elec	2600	Ideco 2500	1900	23,000
Continental Shelf Drlg Corp	Belle Claire	dsl	1700	Beth 1013	1950	18,000
Continental Drlg Co	6	dsl	650	Emsco GB-500	650	11,000
Cron & Gracey Corp	4	dsl	1450	"Oilwell" 96	1290	15,000
Crown Rigs Inc	Bge 2	dsl	1000	Beth MC-450	1000	11,500
Delta Drlg Co	19	stm	1200	Natl 34-10-FE	1690	15,000
Doc Drlg Corp Blackie Drlg Co Inc Neva-Andre Drlg Corp	Bge DOC	dsl	1500	Beth Tornado	1500	15,000
	Bge NEVA	dsl	1500	Beth 1013	1500	18,000
Falcon Seaboard Drlg Co	12	stm	1200	Alco BIW 12	—	25,000
C G Glasscock Drlg Co	14	dsl	1500	Natl 75	900	12,000
Gracey-Hellums Corp	Bge 3	dsl	1775	Unit U-12-20	1800	20,000
Grey Wolf Drlg Co	3	stm	1050	Alco BIW 12	—	13,500
Win Hawkins Drlg Co	5	dsl	200	Ideco PR1050	900	15,000
Kelly Drlg Co Inc	1	stm	600	Ideco Jr Gnt	1200	15,000
	2	pwr	600	"Oilwell" 96	1500	18,000
	3	pwr	825	"Oilwell" 96	1500	18,000
Penrod Drlg Co	33	gas-btne	—	—	1230	12,000
	46	dsl-elec	1250	Emsco ECB	1250	20,000
	47	dsl-elec	1250	Emsco EDA	1250	20,000
The Power Rig Drlg Co	Bge 6	gas-btne	800	Emsco GB-500	—	11,000
Rowan Drlg Co Inc	Bge 3	dsl-elec	2150	Emsco EDA	3455	20,000
	Bge 20	dsl	1120	Natl 75	1300	12,000
Shoreline Drlg Co Inc	Bge 6	dsl-elec	1700	Natl 23-9	1700	16,000
Southeastern Drlg Corp	9-Bge 2	dsl	1200	"Oilwell" 96	1600	18,000
Carnes W Weaver Drlg Co	Bge 1	dsl	2000	"Oilwell" 96	1700	16,000
C B Webster Drlg Co	4	stm	1200	Natl FE-34-10	1200+	15,000
	8	stm	1600	Natl FE-34-10	1200+	15,000
Wheless Drlg Co	7	stm	1000+	Emsco UBLS	1000+	15,000
	Bge 8	dsl	1300	Natl 130	1455	16,000
	15	dsl	1975	Natl 130	1455	16,000
Union Parish						
Monroe Drlg Co Inc	1	stm	260	Natl U-2	—	12,000
Vermilion Parish						
Brewster-Bartle Drlg Co Inc	14	dsl	—	Natl 125	—	16,000
Circle Drlg Co Inc	5	gas-btne	1200	Brwstr N-12	1440	15,000
Comet Drlg Co	1	stm	1200	Ideco Big Gnt	—	16,000
Crown Rigs Inc	Bge 1	dsl	1200	Beth 1013	1200	15,000
Harry L Edwards Drlg Co	Bge 10	dsl	—	Ideco PR-1050	—	16,000
Falcon Seaboard Drlg Co	1	stm	1200+	Emsco ECA	—	25,000
	Bge 4	dsl-elec	—	Beth B-3661	2000	22,000
C G Glasscock Drlg Co	4	dsl	1700	Natl 125	—	16,000
Nicklos Drlg Co	11	stm	—	Natl	—	17,000
	15	gas-btne	—	Natl 80	1000	13,000
Stewart & Gouger Drlg Co	Bge 1	pwr	—	Natl 130	1800	15,000
C B Webster Drlg Co	7	stm	1600	Emsco ECA-10½	1200+	15,000
Webster Parish						
Butler-Johnson Inc	1	gas-btne	650	Brwstr N-75	1005	10,000
Crow Greyhound Drlg Co Inc	3	dsl	1000	Brwstr N-7	825	8,000
Penrod Drlg Co	11	gas	—	—	1425	12,000
	35	stm	—	—	—	15,000
Williams Drlg Co Inc	1	dsl	278	Wlsn Mogul	172	4,000
MICHIGAN						
Barry County						
Gordon Drlg Co	S-7	dsl	300	Crdwll S	300	4,500
Cheboygan County						
Gordon Drlg Co	7	gas-LPG	500	"Oilwell" 64-B	400	5,000
Crawford County						
Fen-Par Expl Co Inc	2	dsl	100	Failing 1500	100	1,500
Union Rotary Corp	8	dsl	475	Natl 50	575	7,500
Hillsdale County						
Union Rotary Corp	4	dsl	475	Natl 50	575	7,500
Isabella County						
Gordon Drlg Co	8	gas-LPG	600	Natl 50-A	500	9,000
Union Rotary Corp	6	dsl	475	Natl 50	575	7,500
Kent County						
Gordon Drlg Co	1	gas-LPG	250	"Oilwell" 64	225	4,000
Mason County						
Fen-Par Expl Co Inc	1	dsl	100	Failing 1500	100	1,500
Newaygo County						
Bernhardt Drlg Co	1	dsl	300	Failing 2500	300	3,500/2⅛"
Osceola County						
Gordon Drlg Co	11	dsl	600	Wlsn Roadair	500	10,000
St. Clair County						
Union Rotary Corp	5	dsl	475	Natl 50	575	7,500
Tuscola County						
Gordon Drlg Co	3	gas-LPG	500	"Oilwell" 64-B	400	5,000
Wayne County						
Eakle & Holder Drlg Co	2	dsl	400	Emsco G-300	400	5,500
Union Rotary Corp	3	gas-LPG	200	Natl 40	180	4,000
MISSISSIPPI						
Adams County						
Dorris Ballew Inc	2	dsl	760	Wlsn Titan	1300	12,500
Fortenbery Drlg Co Inc	1	dsl	500	Ideco H-40	300	7,500
	4	dsl	500	Ideco H-30	275	7,000
Justiss-Mears Oil Co Inc	6	dsl	250	Emsco G-250	325	7,000/4"
	8	gas	300	Emsco G-250	325	7,000/4"
	9	gas	650	Emsco GA-300	560	11,000/4"
Petersen Petroleum Corp	5	gas	320	Crdwll S	350	6,000
Wilson Drlg Co Inc	1	dsl	212	Ideco H-35-D	424	8,500/3½"
Chickasaw County						
Dorris Ballew Inc	8	dsl	1380	Natl 125	1725	16,000
Clarke County						
Dorris Ballew Inc	4	dsl	760	Wlsn Titan	1900	15,000
Clay County						
Drlg & Expl Co of Del Inc	37	gas-gaso	1200	Emsco GB-800	900	12,000
Jefferson Davis County						
Larco Drlg Co	6	dsl	1200	"Oilwell" 96	1600	18,000
Forrest County						
A W Williams Drlg Co Inc	1	dsl	186	Joy 300	200	5,500/2⅛"
Franklin County						
Eagle Drlg & Dev Co	2	dsl	600	Unit U-15	600	8,500
Greene County						
Crow Drlg & Prod Co	16	dsl	1100	Brwstr N-10	1000	12,000
Jett Drlg Co Inc	111	dsl	2000	Natl 125	1200	15,000
Hinds County						
Larco Drlg Co	7	gas	900	"Oilwell" 96	1000	12,500

C. B. WEBSTER

DRILLING CO.

Houston, Tex.
San Jacinto Bldg.
CApitol 4-9346

Lafayette, La.
1300 St. Mary St.
CEnter 4-3406

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Jasper County						
Zach Brooks Drlg Co	8	gas	2600	Brwstr N-12	2600	18,000
Gulf Coast Drlg & Explo Inc	3	dsl	900	Natl 80-B	900	12,500
Jefferson County						
Gulf Coast Drlg & Explo Inc	1	dsl	900	Natl 80-B	900	12,500
Jett Drlg Co Inc	107	dsl	—	—	400	7,000
Jones County						
Drlg & Expl Co of Del Inc	39	gas-gaso	1200	Emsco J-1100	1050	15,000
Marshall R Young Drlg Co	7	stm	2888	Natl 34	1480	16,000
Lamar County						
Gulf Coast Drlg & Explo Inc	4	dsl	800	Natl T-32	800	6,500
Lawrence County						
Marshall R Young Drlg Co	11	—	945	Wlsn Titan	1122	14,000
Lincoln County						
Marshall R Young Drlg Co	1	—	750	Natl 75	648	10,000
	3	—	900	Natl 75	830	10,000
	6	stm	2888	Natl 34	1480	16,000
	8	—	945	Wlsn Titan	1122	14,000
	12	—	740	Natl 50-A	558	8,000
Pearl River County						
Crawford Drlg Co	3	stm	—	"Oilwell" 9	500	10,500
Larco Drlg Co	5	gas	800	"Oilwell" 76	1000	10,000
Perry County						
Zach Brooks Drlg Co	1	gas-btne	1350	Brwstr N-95	1350	14,000
Rankin County						
Arrow Drlg Co	5	gas	1250	Emsco	—	14,000
Simpson County						
Jett Drlg Co Inc	108	dsl	—	—	1000	12,000
	110	dsl	—	—	1200	14,000
Smith County						
Larco Drlg Co	4	dsl	1200	"Oilwell" 96	1600	18,000
Marshall R Young Drlg Co	5	—	945	Wlsn Titan	1122	14,000
Walthall County						
Gulf Coast Drlg & Explo Inc	2	dsl	1200	Natl 110	1200	14,000
Warren County						
Drlg & Expl Co of Del Inc	23	gas-gaso	1000	Natl 100	900	12,000
	41	gas-gaso	1500	Emsco J-1100	1050	15,000
Wayne County						
Drlg & Expl Co of Del Inc	35	gas-gaso	1200	Emsco GB-800	900	12,000
Larco Drlg Co	2	dsl	1200	"Oilwell" 96	1200	14,000
Reading & Bates Inc	3	gas-btne	900	Natl 75	1020	11,000
Sunnyland Contr Co Inc	7	dsl	—	Ideco H-40	450	8,000
	11	dsl	—	Ideco H-750	520	11,000
Wilkinson County						
Fortenbery Drlg Co Inc	5	dsl	500	Wlsn Giant	350	9,000
Sunnyland Contr Co Inc	8	gas-gaso	—	Crdwll D	312	8,000
Yazoo County						
Gulf Coast Drlg & Expl Inc	5	—	—	—	—	—
A W Williams Drlg Co Inc	2	dsl	495	Frnks 6000	495	8,500/4"
MONTANA						
Carbon County						
Hose-Austin Drlg Corp	1	dsl	350	Emsco GB-250T	450	6,000
Signal Drlg & Expl Inc	5	gas-btne	—	Natl 80	1400	14,000
True Drlg Co	9	gas-gaso	1200	Unit U-40	1200	11,000
Fallon County						
Zach Brooks Drlg Co	3	dsl	900	Brwstr N-7	900	8,500
	6	dsl	1300	Brwstr N-75	1300	12,500
Roden & McRae Drlg Corp	3	dsl	1175	Emsco GB-800	900	12,500
	4	dsl	1175	Emsco GB-800	900	12,500
Rowan Drlg Co Inc	5	gas-btne	840	Natl 75	1120	11,000
J D Sprecher	6	dsl	750	Emsco A-550	750	9,000
Garfield County						
Will I Lewis Drlg Co	5	dsl	1000	"Oilwell" 76	1000	12,000
Glacier County						
Brinkerhoff Drlg Co	8	dsl	1200	Natl 110	1200	15,000
Oien Oil Corp	3	dsl	500	Natl T-20	280	5,000
Golden Valley County						
Signal Drlg & Expl Inc	1	dsl	500	Unit U-15	625	8,000
McCone County						
Helmerich & Payne Inc	15	dsl	975	"Oilwell" 76	1000	11,000
Pondera County						
Grannell Drlg Co	1	dsl	450	Unit U-15	450	6,000
Powder River County						
Anschutz Oil Co Inc	9	gas	800	Natl 50-A	600	8,500
Roosevelt County						
Zach Brooks Drlg Co	5	dsl	800	Brwstr N-7	800	8,500
Marvin S Ridgeway	—	gaso	—	Mayhew 1000	—	1,000/2½"
Rosebud County						
Fitzpatrick Drlg Co Inc	2	dsl	500	Unit U-22	500	6,500
	3	dsl-btne	300	Natl T-20	200	5,500
Hose-Austin Drlg Corp	2	dsl	250	Emsco GB-160T	250	5,000/3½"
	3	gas	450	Unit U-15	550	7,000
Sheridan County						
Helmerich & Payne Inc	33	gas	850	"Oilwell" 76	1100	11,000
J D Sprecher	4	dsl	1000	Natl 80-B	1000	12,000
Teton County						
Anschutz Oil Co Inc	11	gas	1000	Wlsn Giant	700	8,500
Wibaux County						
Hewit-Gulick Drlg Co	1	dsl	970	Natl 50-A	600	8,000
	2	dsl	970	Natl 80	900	12,000
NEBRASKA						
Banner County						
Brinkerhoff Drlg Co	10	dsl	275	Natl T-32	275	5,500
Garvey Drlg Co	16	dsl	300	Wlsn Roadair	450	7,000/3½"
	17	dsl	300	Wlsn Roadair	450	7,000/3½"
Lewis Bros Inc	2	dsl	376	Unit U-15	476	6,500
Lohmann-Johnson Drlg Co Inc	1	dsl	300	Natl 50	480	5,500
McDaniel Drlg Co	1	dsl	350	Ideco H-40	350	6,000
Cheyenne County						
Brack Drlg Co Inc (Colo)	4	dsl	—	—	254	5,500
Garvey Drlg Co	20	dsl	300	Wlsn Mogul 42	450	7,000/3½"
Don M Rounds Drlg Co Inc	1	dsl	500	Natl 50	500	6,000
Kimball County						
Herndon Drlg Co	2	gas	600	Natl 50-A	750	10,500
Don Johnston Drlg Co	4	gas-btne	650	Natl 50	650	7,500
Miracle-Fifer Drlg Co	1	btne	300	Unit U-15	660	8,500
Strain Drlg Co	1	dsl	325	Unit U-15	600	7,500
Richardson County						
Nemaha Oil Co	1	dsl	370	Frnks SAL 3000	370	4,500/3½"
NEVADA						
Eureka County						
Colorado Wyoming Drlg Co	1	dsl	300	Natl 50-A	600	9,000
NEW MEXICO						
Bernalillo County						
Taylor Expl Co Inc	1	btne	—	Mayhew	125	3,000
Chaves County						
Donnell Drlg Co	14	btne	—	Ideco H-40	370	4,000
J E Jones Drlg Co	2	gas	500	Unit U-15	663	7,500
Eddy County						
Johnn Drlg Co	6	gas	850	Brwstr N-95	1300	14,000
Carl B King Drlg Co of Tex	12	gas-gaso	1000	Natl 75	1000	12,500
Lee Drlg Co	4	gas-gaso	700	Natl 75	—	10,000
Parker Drlg Co	45	gas	—	Natl L-125	1400	15,000
Rowan Drlg Co Inc	12	gas-btne	1260	Natl 100	1680	14,000
Urice Drlg Co	6	gas-btne	280	Wlsn Super	145	3,000
Lea County						
Bickerstaff & Tibbets Drlg Co	7	gas	450	Emsco G-36	450	6,000
Brantly Drlg Co Inc	7	gas	975	Beth 450	1125	12,500
Cactus Drlg Corp of Tex	4	gas-btne	1050	"Oilwell" 76	1050	12,500
	7	gas-btne	1275	"Oilwell" 96	1050	15,000
	9	gas-btne	800	Brwstr N-75	—	12,500
	10	gas-btne	700	Beth M-58	700	9,000
Clark Dale Drlg Co Inc	1	gas	—	"Oilwell" 76	1000	12,500
	3	gas	—	"Oilwell" 66	660	10,000
Delta Drlg Co	6	gas-btne	800	Emsco J-750	750	9,500
	9	gas-btne	936	Natl 100	800	12,000
Denver Drlg Corp	1	gas	370	Crdwll EC	370	5,000
Donnell Drlg Co	5	gas-btne	650	Unit U-15	650	8,000
Durham Drlg Co Inc	3	gas	1150	Unit U-20	1300	14,000
	4	gas	1250	Ideco 7-11	1450	15,000
Gardner Bros Drlg Co Inc	12	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	18	dsl	955	Unit U-914A	1800	15,000
	25	gas-gaso	775	Unit U-914A	1125	15,000
Helmerich & Payne Inc	25	gas	1100	"Oilwell" 96	1100	14,000
	32	gas	1100	"Oilwell" 96	1100	14 000
	43	gas	900	"Oilwell" 76	1100	11,000
Hissom Drlg Co	1	gas	600	Emsco 500	600	8,500
Keating Drlg Co	11	gas-gaso	—	—	650	8,500
Kerr-McGee Oil Ind Inc	7	gas	900	Natl 75	818	11,500
Carl B King Drlg Co of Tex	7	gas-gaso	1000	Natl 100	1000	13,500
	20	gas	2100	"Oilwell" 96-16	2100	20,000
Llano Drlg Co	1	dsl	1175	"Oilwell" 96	1200	15 000
	5	gas	—	Natl 100	1050	14,000
Lowe Drlg Co	1	gas	500	Unit U-15	—	7,500
	2	gas	750	Natl 75	—	10,000
	4	gas	1000	Natl 125	—	12,500
	8	gas	1200	Natl 80	—	12,500
	9	gas	2000	Natl 125	—	17,000
	10	gas	1000	Wilson	—	12,500
McAlester Fuel Co	—	btne-gas	—	Emsco J-1100	1050	14,000
	—	btne-gas	—	Natl 100	1050	14,000
B L McFarland Inc	5	gas	700	Brwstr N-75	—	12,000
	11	gas	1000	Natl 100	—	13,000
McQueen & Stout Drlg Co	15	LPG	225	Crdwll RL	185	4,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Makin Drlg Co	1	gas-gaso	975	Wisn Titan	1300	13,000
	2	gas-gaso	650	Wisn Giant	600	8,000
	3	gas-gaso	975	Wisn Titan	1300	13,000
	4	gas-gaso	975	Wisn Titan	1300	13,000
	5	gas-gaso	700	Wisn Titan	700	10,000
	6	gas-gaso	650	Wisn Giant	600	6,700
	7	gas-gaso	975	Wisn Titan	1300	12,000
	8	gas-gaso	1050	Wisn Titan	1050	13,000
	9	gas-gaso	450	Wisn Giant	400	5,000
	10	gas-gaso	650	Wisn Giant	600	8,000
Moran Oil Prod & Drlg Corp	1	gas	—	Unit U-15	800	8,500
	4	gas	—	Unit U-34	300	5,000
Nichols Drlg Co	6	gas-btne	1050	Wisn Titan	1050	15,000
Parker Drlg Co	28	gas	—	Natl L-50	700	9,000
	33	gas	—	Natl 75	1000	11,000
	42	gas	—	Natl L-100	1400	14,000
	49	gas	—	Natl L-125	1400	15,000
	51	gas	—	Natl 50	700	9,000
	52	gas	—	"Oilwell" 76	1400	12,500
	54	gas	—	Natl L-125	1400	20,000
	55	gas-elec	—	Natl L-130	2000	20,000
Fred Pool Drlg Co	3	gas	225	Wisn Giant	250	5,500
Rowan Drlg Co Inc	7	gas-btne	1260	Natl 100	1680	14,000
Schafer Drlg Co	3	gas-gaso	400	Unit U-15	600	10,000
Sharp Drlg Co	18	gas	1350	Beth MC-950	1350	15,000
Warton Drlg Co	3	gas	970	Natl 110	1600	14,000
Western Drlg Co Inc	16	dsl	600	Emsco 350	290	6,000
Western Serv Drlg Co Inc	8	gas-btne	600	Beth MC-650	700	11,000
S P Yates Drlg Co	1	dsl	350	Unit U-34	—	5,000
	2	dsl	350	Unit U-15	—	6,500
McKinley County						
Carmack Drlg Co	7	dsl	300	Natl T-12	300	4,000
Rio Arriba County						
D-K Drlg Co	2	gas	675	Natl 50	675	7,500
Empire States Drlg Corp	1	gas	225	Unit U-34 Trlr	225	5,000
Fleeger Drlg Inc	1	dsl	325	Beth Twister	600	8,500
	6	dsl	450	Unit U-15	600	8,500
Great Western Drlg Co	32	dsl	353	Unit U-15	750	7,500
	36	gas-gaso	320	Unit U-15	675	7,500
H B Lynn Drlg Corp	1	gas-btne	700	Natl 50	—	7 500
Nichols Drlg Co	3	gas-btne	700	Natl 50-A	700	9,000
Paul F Rutledge	2	gas	650	Beth M-58	650	10,500
	5	gas	650	Natl 50	650	7,000
Roosevelt County						
Great Western Drlg Co	12	gas-gaso	1350	Unit U-20	1755	16,000
San Juan County						
Arapahoe Drlg Co	3	gas-btne	300	Wisn Mogul	275	5,000
Brannon & Murray Drlg Co	2	gas-LPG	550	Emsco GA-350	550	6,500
	3	gas-LPG	350	Brwstr N-4	250	5,000
Brinkerhoff Drlg Co	23	dsl	375	Natl T-20	275	5,500
	24	dsl	375	Natl T-20	275	5,500
Carroll Drlg Co Inc	6	dsl	—	Unit U-15	—	6,500
	8	dsl	—	Natl 75	—	9,500
	10	dsl	—	Emsco	—	9,500
Durham Drlg Co Inc	1	gas	500	Unit U-15	660	8,500
Empire States Drlg Corp	2	gas	530	Ideco H-35	530	6,500
	3	gas	225	Crdwll L	225	4,000
Exploration Drlg Co	4	gas	625	Unit U-15	600	8,000
Fleeger Drlg Inc	7	dsl	360	Beth 45-E	500	5 000
Foree Drlg Co	1	gas-btne	325	Unit U-34	300	4,500
	2	gas-btne	300	Unit U-15	600	7,500
	3	gas-btne	325	Unit U-15	600	7,500
	4	gas-btne	325	Emsco GA-500	500	7,500
Gardner Bros Drlg Co Inc	9	gas-btne	450	Unit U-15	675	7,000
	19	gas-btne	185	Crdwll R	200	3,300
Great Western Drlg Co	31	gas-gaso	307	Unit U-15	840	9,000
Herndon Drlg Co	4	gas	480	Emsco G-450	630	7,000
H B Lynn Drlg Corp	2	gas-btne	700	Natl 50	—	7,500
	3	gas-btne	700	Natl 50	—	7,500
Miracle-Fifer Drlg Co	2	btne	300	Unit U-15	760	6,500
	3	btne	300	Unit U-34	420	6,000
Moran Bros Inc	3	gas	700	Emsco GB-350	750	8,500
	10	gas	550	Emsco GA-350	650	8,500
Schafer Drlg Co	4	gas-gaso	200	Unit U-34	200	6,000
San Miguel County						
Sojourner Drlg Corp	1	btne	218	Unit U-15	—	7,500
NEW YORK						
Steuben County						
Delta Drlg Co	39	gas-btne	500	Natl 75	1000	9,500
NORTH DAKOTA						
Billings County						
Helmerich & Payne Inc	29	gas	950	Natl 75-CA	1100	11,000
Paul F Rutledge	3	gas	650	Beth M-450	650	12,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Bottineau County						
Calvert Drlg Inc	22	gas-btne	320	Ideco H-35	330	5,500
Cardinal Drlg Co (Bismarck)	1	dsl	320	Emsco GB-250	320	5,500
	2	dsl	320	Natl T-20	320	5,000
	3	dsl	280	Frnks	280	3,000
Penrod Drlg Co	9	dsl	—	—	385	6,000
Signal Drlg & Expl Inc	4	gas	300	Ideco H-25	300	4,200
Burke County						
Anschutz Oil Co	5	dsl	300	Wisn Giant	280	5,500
Brinkerhoff Drlg Co	2	dsl	350	Natl 50-A	400	7,000
	21	dsl	650	Emsco GC-500	800	10,000
Cactus Drlg Corp Ltd	1	gas-btne	450	Brwstr N-55	450	7,000
	2	gas-btne	675	Unit U-15	675	8,500
Calvert Drlg Inc	23	dsl	350	Ideco H-526	600	8,500
	24	gas-btne	600	Unit U-15	600	9,000
	25	gas-btne	1050	Beth 810	1100	12,500
Lohmann-Johnson Drlg Co Inc	4	dsl	300	Unit U-15	440	5,500
M-H-O Drlg Co	8	gas-btne	800	Unit U-15	800	8,000
Penrod Drlg Co	19	dsl	—	—	730	9,000
	21	dsl	—	—	385	6,000
Signal Drlg & Expl Inc	3	dsl	370	Unit U-36-A	420	7,500
Golden Valley County						
Carpenter-Trant Drlg Co	5	dsl	900	Brwstr	900	12,000
McKenzie County						
Anschutz Oil Co Inc	14	gas	900	Brwstr N-7	600	10,000
Brinkerhoff Drlg Co	5	dsl	650	Emsco J-750	800	10,000
Helmerich & Payne Inc	8	gas	600	Natl 55	800	9,000
Gabe McCall Drlg Co	3	gas	1200	Natl 80	1200	10,000
Penrod Drlg Co	31	dsl	—	—	1200	10,000
Rowan Drlg Co Inc	23	gas-btne	1140	Natl 75	1503	11,000
Paul F Rutledge	1	gas	975	Beth M-450	925	12,000
J D Sprecher	2	dsl	900	Emsco J-750	900	9,500
Renville County						
Anschutz Oil Co Inc	12	gas	830	Brwstr N-45	530	7,000
Signal Drlg & Expl Inc	2	dsl	370	Unit U-36-A	420	7,500
Stark County						
R L Manning Co	8	dsl	550	Emsco G-500	550	7,500
Williams County						
Exploration Drlg Co	6	gas	310	Beth S-50	200	5,500
	9	gas	310	Beth S-50	250	5,500
Rowan Drlg Co Inc	15	gas-btne	1140	Natl 75	1503	11,000
	27	gas-btne	1350	Natl 125	1530	15,000
OHIO						
Ashtabula County						
Union Rotary Corp	7	gas-LPG	220	"Oilwell" 64	220	6,000
Monroe County						
D J Branyan Co	1	dsl	600	Wichtex E-75	145	3,000
Wayne County						
D B Lesh Drlg Co	2	dsl	320	Natl T-25	320	5 500
OKLAHOMA						
Alfalfa County						
Barrett Petroleum Co	2	gas-gaso	—	Natl 50	450	6,800
Davon Drlg Co	5	gas-LPG	400	Brwstr N-45	320	7,500
Falcon Seaboard Drlg Co	8	gas-btne	450	Beth 450	900	10,000
Summit Drlg Corp	2	dsl	—	Frnks SAL 5000	800	5,000
Viersen & Cochran	12	gas	325	Natl T-25	225	5,500
Beaver County						
Arrow Drlg Co	10	gas	560	Emsco 500	—	8,000
Big Chief Drlg Co	24	gas	750	Unit U-15	800	9,500
Gabbert-Jones Drlg Co	2	gas	450	Emsco 350	450	7,000
Harper-Turner Drlg Co	1	gas	650	Wisn Titan	—	11,000
	8	gas	480	Natl 50	—	8,000
Helmerich & Payne Inc	7	gas	500	Emsco GB-500-82	700	9,000
Holm Drlg Co	6	dsl	750	Wisn Roadair	600	8,500
Lynn Drlg Co	2	gas-btne	425	Natl 75	700	10,000
Midwestern Drillers Inc	3	dsl	370	Unit U-15	750	8,500
	7	dsl	370	Unit U-15	750	8,500
Nichols Drlg Co	2	gas-btne	700	Natl 55	700	12,000
Nye & Snell Drlg Co	2	dsl	320	Wisn M-46	320	5,000
Schafer Drlg Co	1	gas-gaso	1200	Unit U-40	900	12,000
Unit Drlg Co	2	gas-btne	900	Unit U-15	900	8,500
Webster Drlg Co	7	gas-btne	700	Unit U-15	700	8,500
Beckham County						
Beckman Inc	17(wo)	gas	150	MIW P-42	200	10,000/2⅛"
Big Chief Drlg Co	33	gas	1250	Natl 55	1250	11,000
Helmerich & Payne Inc	47	gas-btne	2000	"Oilwell" 96	2000	20,000
Parker Drlg Co	57	gas	—	Emsco 750	1000	10,000
Bryan County						
Viersen & Cochran	4	gas	600	Natl 75	650	10,500
Caddo County						
Arrow Drlg Co	25	gas	840	Ideco 1000	—	10,000
Big Chief Drlg Co	2	gas	1875	Natl 125	1815	16,000
Bolin Oil Co & D H Bohn	3	gas	350	Wisn Giant	225	5,000

WORLD-WIDE SERVICE

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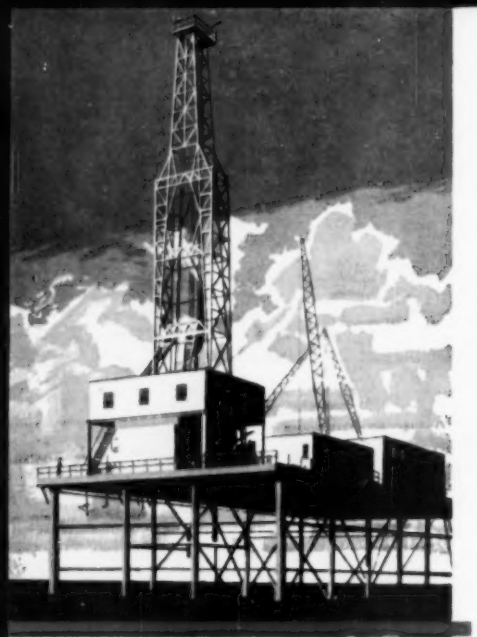
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

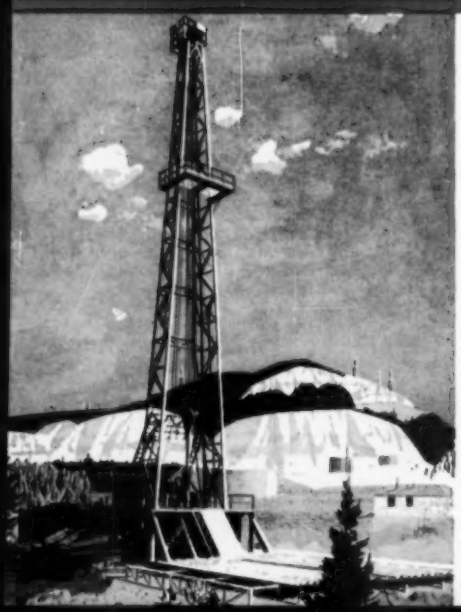
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Helmerich & Payne Inc	38	gas	950	Natl 80	1100	11,000
Howell & Howell	9	gas	1600	Emsco A-1500	2500	25,000
G H Ray Well Serv	1	prop-gas	200	Wilson	200	4,500
Carter County						
Berry Drlg Co	1	dsl	350	Wlsn Giant	500	6,500
Crowe Drlg Co	2	gas	200	Natl T-12	175	4,000
Catline Dodson Drlg Inc	1	—	450	Beth S-45	220	5,000
Fain-Porter Drlg Corp	3	gas	375	Emsco GA-250	400	6,000
Flournoy-Haston Drlg Co Inc	1	gas	275	Unit U-34	200	4,500
Graves Drlg Co	1	dsl	300	Frnks 4000-A	330	3,500
	2	gas	185	Frnks	125	2,000
Kingery Drlg Co Inc	10	btne-gas	300	Wilson	375	4,500
Kirkpatrick Oil Co	1	gas	300	Beth S-60	258	7,500
Ward S Merrick	1	gas	300	Wlsn Giant	—	5,000
Nelson Drlg Co	3	gas	225	Unit U-34	400	4,500
Perkins Bros Drlg Co	3	gas-btne	400	Beth S-60	370	7,500
Riceland Corp	4	gas	1200	Brwstr N-95	—	16,000
	5	gas	800	Brwstr N-75	—	10,000
Sherin Drlg Co	5	gas-gaso	750	Natl 55	750	9,000
Cimarron County						
Garvey Drlg Co	9	dsl	175	Wlsn Giant	296	5,000
Latexo Drlg Co Inc	1	gas-btne	370	Beth S-55 Twstr	370	7,500
Lewis Drlg Co	4	dsl	450	Crdwll	450	6,000
Cleveland County						
An-Son Drlg Co	2	gas	600	Unit U-15	700	9,000
Big X Drlg Co Inc	1	gas-gaso	750	Beth MC-450	750	9,000
Bryant-Hayward Drlg Co	3	gas	700	Unit U-15	700	9,500
Calvert Drlg Inc	18	gas-btne	350	Unit U-15	600	8,500
Davon Drlg Co	3	gas-LPG	500	Brwstr N-7	750	10,000
N V Duncan Drlg Co	2	gas	600	"Oilwell" 64-B	600	9,000
	4	gas	600	Beth 450	600	9,000
T T Eason Co Div Eason Oil Co	12	gas	1000	Natl 80-B	1000	12,000
	14	gas	750	Emsco 6-B-500	750	9,000
Fain-Porter Drlg Corp	4	gas	575	Emsco GB-500	600	8,000
Garr-Woolley Co	3	gas-btne	320	Emsco 500-GB	510	9,500
	4	gas-btne	320	Emsco 500-GC	510	9,500
Garvey Drlg Co	21	dsl	500	Unit U-15	640	8,500
Goff-Leeper Drlg Co	2	gas	225	Brwstr N-4	350	6,000
Harper-Turner Drlg Co	4	gas	450	Natl 80	—	7,500
Holliman Drlg Co	5	dsl	825	Emsco GB-800	1000	11,000
Kirkpatrick Oil Co	4	gas	504	Wlsn Giant	504	10,500
Nichols Drlg Co	9	gas-btne	700	Natl 50-A	700	10,000
	10	gas-btne	450	Wlsn Giant	450	7,500
Nuckolls-Bell Drlg Co	3	dsl	600	Ideco H-525	704	9,000
O'Rourke-McGirl Drlg Co	2	gas-btne	—	Unit U-15	800	8,000
Sabre Drlg Co	3	dsl	285	Unit U-36	560	7,500/4"
Coal County						
Sherin Drlg Co	4	gas-gaso	1000	Natl 100	1050	12,000
Tommy Ward Drlg Co	1	gas-btne	300	Unit U-35	426	7,000
Comanche County						
Alan Drlg Co	3	gas	275	Wlsn Mogul	145	3,500
R V Dillard Drlg Co	1	gas	—	Wichtex	145	3,000
Cotton County						
R Benton Ross Inc	1	dsl	210	Wilson	165	3,100
Creek County						
Davon Drlg Co	4	gas-LPG	200	Brwstr N-2	290	6,500/2⅞"
Doak Drlg Co	2	btne-gas	270	Natl T-20	250	4,500
Herring & Davis	2	gas-gaso	100	Mayhew 2000	100	2,000/2⅞"
J & J Drlg Co	1	gas-btne	275	Beth S-45	450	4,500
Scat Drlg Co	1	dsl	300	Emsco 300	—	5,500
	2	dsl	300	Wichtex R-6	—	5,500
Ellis County						
Helmerich & Payne Inc	36	gas	500	Emsco GB-500-52	700	9,000
Keating Drlg Co	15	gas-gaso	—	—	675	9,000
J S Montgomery	3	gas	1100	Natl 80	1100	12,000
Garfield County						
Hayward Drlg Co	1	dsl-gas	165	Wilson	125	2,500
Helmerich & Payne Inc	46	gas	500	Emsco GB-500-52	700	9,000
Lynn Drlg Co	4	gas-btne	300	Natl 50	675	8,000
Garvin County						
Big X Drlg Co Inc	2	gas-gaso	750	Natl 55	750	10,000
Dearing Inc	1	gas-btne	—	Natl 50	—	7,000
	2	gas-btne	—	Natl 100	—	15,000
	5	gas-btne	—	Wlsn Giant	—	6,000
Catline Dodson Drlg Inc	2	gas	675	Unit U-15	675	9,000
N V Duncan Drlg Co	7	gas	250	Natl 50	450	7,500
Flournoy-Haston Drlg Co	2	gas-btne	300	Unit U-15	650	8,500
Garvey Drlg Co	6	dsl	275	Unit U-15	640	8,500
General Drlg Co	5	—	300	Natl	—	7,000
Goff-Leeper Drlg Co	3	gas	450	Unit U-15	450	8,000
Goldsmith Drlg Co	2	—	400	Natl 50	—	8,000
Hap Drlg Co	1	gas	350	Emsco GB-500	550	8,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Helmerich & Payne Inc	24	gas	950	Natl 80	1100	11,000
Holliman Drlg Co	6	gas	750	Wlsn Atlas	950	10,000
Nelson Drlg Co	4	gas	650	Unit U-15	650	9,000
Nichols Drlg Co	5	gas-btne	1350	Natl 75-CA	1350	11,000
Parker Drlg Co	56	gas	—	Natl L-50	700	9,000
Sherin Drlg Co	1	gas-gaso	500	Unit U-15	600	8,000
	2	gas-gaso	500	Unit U-15	600	8,000
Viersen & Cochran	7	gas	600	Wlsn Titan	650	10,500
	8	gas	980	Emsco J-1000	975	14,000
Chester H Westfall Drlg Co	1	gas-gaso	625	Unit U-15	700	10,400
Grady County						
A & P Drlg Co Inc	2	gas-gaso-btne	500	Emsco GB-500	500	8,000
Big Chief Drlg Co	29	gas	1875	Emsco 1250	1815	16,000
	30	gas	1545	Ideco 1050	1515	16,000
	35	gas	2610	Natl 110	2610	18,000
Falcon Seaboard Drlg Co	15	gas-btne	1100	Unit U-20	1200	16,000
Harper-Turner Drlg Co	9	gas	125	Crdwll	—	4,000
Helmerich & Payne Inc	44	gas	1200	"Oilwell" 96	1500	15,000
Viersen & Cochran	9	gas	1200	Emsco J-1250	1590	18,000
Dick Wegener Drlg Contr	4	gas-dsl	1900	Natl 130	1900	22,000
Kidd Williams Drlg Corp	11	gas	775	Wlsn Atlas	1200	12,500
Grant County						
Barrett Petroleum Co	4	dsl	—	Unit U-10	350	5,800
	5	gas-gaso	—	Brwstr N-7	750	8,500
Hap Drlg Co	2	gas	300	Brwstr N-4	200	5,000
Indian Drlg Co	2	dsl	220	Ideco H-35-S	350	5,000
Lohmann-Johnson Drlg Co Inc	8	dsl	300	Natl 32	550	7,500
Tennant Drlg Co	1	gas-btne	450	Frnks 6000	450	6,000
Viersen & Cochran	1	gas	325	Emsco G-300	450	5,800
	6	gas	255	Natl T-25	225	5,500
	14	gas	325	Natl T-25	225	5 500
Webster Drlg Co	5	gas-btne	450	Natl 50	450	7,500
Harper County						
Arrow Drlg Co	1	gas	860	Ideco 1000	—	11,500
Baker & Taylor Drlg Co	6	gas-btne	750	Emsco G-450	750	9,500
Barrett Petroleum Co	1	gas-gaso	—	Natl 50	450	6,800
Beckman Inc	3(wo)	gas	150	MIW P-42	200	10,000
Bryant-Hayward Drlg Co	1	gas	675	Natl 50	675	8,500
Calvert Drlg Inc	19	dsl	350	Unit U-15	600	8,500
T T Eason Co Div Eason Oil Co	15	gas	450	Emsco T-250	225	6,000
R W Rine Drlg Co	5	gas-btne	520	Brwstr N-55	550	7,500
Summit Drlg Corp	3	gas	—	Emsco 450	450	7,000
Viersen & Cochran	5	gas	500	Natl 50	650	9,000
Hughes County						
Poteet Wysor & Eckles Inc	1	gas-btne	225	Unit U-34	185	5,000
Smiley & Little Drlg Co	4	gas	100	Wilson	100	2,600
Kay County						
Badger Drillers Inc	1	dsl	280	Natl T-32	320	6,500
Glendale Drlg Co	1	gas-gaso-btne	320	Unit U-10	330	5,000
Roy Lawrence Drlg Co	1	dsl	340	Frnks Comet	254	5,000
Dave Morgan Drlg Co	—	LPG-gas	350	Natl T-32	320	6,000
Target Drlg Corp	1	gas-btne	225	Unit U-34	195	5,000
Kingfisher County						
Big Chief Drlg Co	27	gas	760	JS&G Spad Spr	760	9,000
Nuckolls-Bell Drlg Co	2	dsl	300	Ideco H-40	352	7,500
Lincoln County						
Austin-Dunham Inc	1	gas-btne	350	Frnks SAL-6000	570	6,000
Barrett Petroleum Co	3	dsl	—	Wlsn Giant	300	5,500
Delaney Drlg Co	1	gas-btne	450	Unit U-15	450	7,500
	2	gas-btne	225	Unit U-34	225	5,000
Frizzell Drlg Co	1	gas-gaso	—	Wilson	600	7,500
Lincoln Drlg Co	1	gas	250	Brwstr N-3	185	4,500
	2	gas	325	Natl T-25	290	6,000
Wm A Norton	1	gas-btne	300	Unit U-10	370	6,000
Patco Drlg Contr	1	dsl	300	Unit U-34	—	4,500
Unit Drlg Co	1	gas-btne	290	Unit U-34	300	5,500
Warren Drlg Co	2	dsl	—	Ideco H-30S	320	5,500
Logan County						
Big Chief Drlg Co	1	gas	450	JS&G Spad "Super"	450	6,500
Bodard Drlg Co	1	gas	225	Unit	185	4,500
Calvert Drlg Inc	15	dsl	260	Ideco H-35	260	5,000
Folk Drlg Co	1	dsl	200	Crdwll RL	200	4,000
Glenn Gillespie & Sons	2	gas-dsl	360	Wlsn Mogul	280	6,000
	6	gas	290	Unit U-34	290	4,500
Harper-Turner Drlg Co	2	gas	450	Natl 50	—	7,500
Patco Drlg Contr	3	gas	450	Unit U-15	—	9,000
Warren Drlg Co	1	gaso	350	Natl T-32	—	7,000
Love County						
Arrow Drlg Co	18	gas	1260	Emsco 1250	—	14,000
Falcon Seaboard Drlg Co	24	gas-btne	—	Beth 950	1365	16,000
	32	gas-btne	1050	Beth 650	1155	16,000
Flournoy-Haston Drlg Co Inc	3	gas	600	Wlsn Atlas	750	10,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Johnn Drlg Co	8	gas	500	Brwstr N-75	700	10,000
Kidd Williams Drlg Corp	5	gas	825	Wisn Atlas	900	10,000
	6	gas	925	Wisn Titan	1000	15,000
Major County						
Perkins Bros Drlg Co	4	gas-btne	1200	Beth 650	1200	12,000
Summit Drlg Corp	1	dsl	—	Emsco 450	480	7,000
Webster Drlg Co	4	gas-btne	750	Emsco 500	750	8,500
	6	gas-btne	600	Beth	600	7,500
Marshall County						
Nelson Drlg Co	1	gas	450	Unit U-15	450	6,500
McClain County						
A & P Drlg Co Inc	1	gas-gaso-btne	450	Emsco G-450	450	7,000
Fain-Porter Drlg Corp	1	gas	750	Wisn Titan	900	12,500
Falcon Seaboard Drlg Co	28	gas	1200	Beth 650	1050	16,000
Fleeger Drlg Inc	2	dsl	320	Wisn Roadair	700	8,500
Flournoy-Haston Drlg Co	4	gas-btne	700	Natl 100	1000	14,000
Goff-Leeper Drlg Co	1	gas	800	Brwstr N-75	800	12,000
	4	gas	850	Wisn Giant	850	12,500
Kerr-McGee Oil Ind Inc	41	gas	970	Natl 75	832	11,500
Parker Drlg Co	37	gas	—	Natl L-100	1400	14,000
	38	gas	—	Natl L-100	1000	14,000
Viersen & Cochran	2	gas	500	Natl 55	650	10,500
	3	gas	600	Natl 75-CA	650	10,500
Chester H Westfall Drlg Co	2	gas-gaso	625	Unit U-15	700	10,400
	3	gas-gaso	625	Unit U-15	700	10,400
McIntosh County						
Reed Drlg Co Inc	4	gas-gaso	300	Unit U-34	290	5,000
Murray County						
Riceland Corp	3	gas	900	Brwstr N-75	—	10,000
Muskogee County						
Bechman Inc	5(wo)	—	180	MIW P-42	175	10,000
Noble County						
An-Son Drlg Co	3	gas	400	Beth Breeze	250	4,500
Chambless-Rosen Drlg Co	1	gas-btne	225	Crdwll RL	200	5,000
Goe Drlg Co	2	gas-btne	200	Wisn	145	3,250
	3	dsl	275	Carson	195	3,500
The Novak Drlg Co	3	gas	265	Brwstr N-45	—	5,000
Patco Drlg Contr	2	dsl	300	Unit U-15	—	7,500
Nowata County						
Overby Drlg Co Inc	1	dsl-btne	180	Mayhew 1000	—	1,000
Okfuskee County						
Riceland Corp	1	gas	250	Ideco H-25	—	3,000
Sabre Drlg Co	4	gas-LPG	225	Brwstr N-3	160	3,500/4"
Oklahoma County						
C H & C Drlg Co	1	gas	300	Unit U-15	680	9,000
Davon Drlg Co	1	gas-LPG	250	Brwstr N-4	300	6,000
Harper-Turner Drlg Co	3	gas	450	Natl 50	—	7,500
Lynn Drlg Co	1	gas-btne	300	Natl 50	450	7,000
Viersen & Cochran	13	gas	325	Natl T-16	175	5,200
Okmulgee County						
Glenn Gillespie & Sons	1	gas	360	Unit U-34	225	4,500
Johnson-Bates Drlg Co	1	gas	245	Unit U-34	300	4,500
Osage County						
Doak Drlg Co	3	btne-gas	270	Natl T-20	250	4,500
Falcon Seaboard Drlg Co	19	gas-btne	185	Unit U-34	194	5,000
Glenn Gillespie & Sons	7	dsl	300	Frnks 658 TRD	225	4,000
John Heard & Co Inc	2	gas-LPG	270	Natl T-12	212	3,500
Indian Drlg Co	1	btne	220	Ideco H-25	250	4,000
Jackson Drlg Co	3	gas	400	Wisn Mogul	400	5,500
Al Johnson Drlg Co	1	btne	325	Mayhew	200	3,500
Mesker Drlg Co	1	gas	214	Joy 300	170	2,500
The Novak Drlg Co	1	gas	225	Brwstr N-4	—	3,500
Overby Drlg Co Inc	3	btne	250	Mayhew 2000	250	2,000
Reed Drlg Co	3	gas-gaso	185	Wilson	145	2,800
Service Drlg Co	9	dsl	320	Natl	—	4,000
	11	LPG	185	Crdwll Trlrmt	125	2,500
Triad Drlg Co	3	gas-btne	250	Beth S-45	250	5,500
Pawnee County						
John Heard & Co Inc	1	gas-LPG	240	Brwstr N-4	212	3,500
Herring & Davis	4	gas-gaso	150	Joy 200-A	150	2,000/2⅛"
Pete Morris Drlg Co	1	dsl-gas	550	Wisn Giant	550	6,000
Payne County						
Dudley & Heath Drlg Co	6	dsl	265	Crdwll S	320	5,500
Foster Drlg Co	1	dsl	265	Natl T-16	265	5,000
Garr-Woolley Co	1	gas-btne	185	Emsco 300	280	5,500
Glenn Gillespie & Sons	3	dsl	425	Wisn Mogul	280	6,000
R L Horn & Sons Drlg Co	3	gas	185	Brwstr N-3	165	5,000
O'Rourke-McGirl Drlg Co	1	gas-btne	—	Unit U-10	450	6,000
Sabre Drlg Co	2	dsl	330	Unit U-34	300	5,000/4"
Pontotoc County						
J G Cantrell Drlg Co	1	gaso	185	Emsco T-160	165	4,000
Don Clawson	1	gas-btne	240	Brwstr N-4	185	3,500
Kingery Drlg Co Inc	3	dsl	210	Wilson	350	4,500
Reed Drlg Co Inc	2	gas-gaso	—	Crdwll D	410	5,500
Pottawatomie County						
Davon Drlg Co	2	gas-LPG	280	Brwstr N-4	320	6,500
Harper-Turner Drlg Co	5	gas	320	Emsco G-300	—	6,000
Holliman Drlg Co	4	gas	255	Unit U-15	500	7,500
Seminole County						
Austin Drlg Co	1	dsl	300	Unit U-34	300	5,500
Garr-Woolley Co	2	gas-btne	255	Emsco 350	378	7,000
Johnson-Bates Drlg Co	2	gas	300	Unit U-34	300	5,000
Melco Drlg Co	1	btne	265	Brwstr N-35	185	5,000
	2	btne	265	Brwstr N-35	185	5,000
R W I T Drlg Co	1	gas-LPG	150	Crdwll	150	3,000/3½"
Reed Drlg Co Inc	1	gas-gaso	220	Unit U-34	235	5,000
	6	gas-gaso	240	Natl T-12	180	4,500+
Seran & Howard Drlg Co	1	gas	225	Beth	200	5,000
Troup & Suttles Inc	2	gas-gaso	200	Wilson	370	5,000
Stephens County						
Beckman Inc	12(wo)	gas	150	MIW P-42	175	10,000/2⅛"
Bryant-Hayward Drlg Co	2	gas	675	Natl 50	675	8,500
	4	gas	900	Brwstr N-75	900	12,000
Crowe Drlg Co	1	gas	175	Wisn Super 38	175	4,000
R A Davenport Drlg Contr	2	gas-btne	145	Wichtex R-4	145	2,500
Holliman Drlg Co	1	gas	500	Unit U-15	900	7,500
	2	gas	350	Unit U-15	550	7,500
	3	gas	255	Unit U-15	600	7,500
Jennings Drlg Co	5	btne-gas	450	Wisn Giant	900	9,000
Nelson Drlg Co	2	gas	620	Wisn Giant	620	7,500
Nichols Drlg Co	1	gas-btne	350	Wisn Giant	350	5,500
	4	gas-btne	450	Wisn Giant	450	7,500
Parker Drlg Co	34	gas	—	Natl L-75	800	10,000
	60	gas-elec	—	Natl L-34x10	2000	2,500
Perkins Bros Drlg Co	2	gas-btne	—	Unit U-15	675	8,500
Star Drlg Co	1	gas	165	Wisn Super	165	2,500
Viersen & Cochran	11	gas	1525	Natl 110	1530	18,500
Tommy Ward Drlg Co	2	gas	300	Beth 350	426	7,000
Dick Wegener Drlg Contr	3	gas	350	Whind B-85	500	10,000
Kidd Williams Drlg Corp	10	gas	1400	Wisn Spr Titan	2100	21,000
Texas County						
Holm Drlg Co	5	dsl	300	"Oilwell" 52T	300	5,500
R W Rine Drlg Co	3	gas-btne	520	Unit U-15	600	7,500
Service Drlg Co	3	LPG	650	Unit U-15	—	8,500
	8	LPG	300	Unit U-34	—	4,500
Tommy Ward Drlg Co	3	gas	350	Brwstr N-35	650	5,000
Tulsa County						
Glenn Drlg Co	3	gas	145	Crdwll S	145	4,000
Mesker Drlg Co	2	gas	185	Joy 300	160	2,500
Washington County						
Herring & Davis	3	gas-gaso	150	Mayhew 2000	150	2,000/2⅛"
Overby Drlg Co Inc	2	dsl-btne	250	Mayhew 2000	—	2,500
Washita County						
Nichols Drlg Co	77	gas-btne	1530	Natl 110	1530	15,000
Sherin Drlg Co	3	gas-gaso	500	Unit U-15	600	8,000
Woods County						
Dudley & Heath Drlg Co	7	dsl	265	Brwstr N-4	320	5,500
Unit Drlg Co	3	dsl	700	Natl 50-A	700	6,500
Woodward County						
Arrow Drlg Co	11	dsl	595	Emsco 500	—	8,000
Nichols Drlg Co	8	gas-btne	650	Natl 50-A	650	9,000
PENNSYLVANIA						
Berks County						
C S Garber & Sons Inc	—	gas-gaso	—	—	32	1,500
	—	gas-gaso	—	—	32	1,500
Bucks County						
C S Garber & Sons Inc	25	dsl	—	Ingersoll	135	400
	26	dsl	—	Ingersoll	135	130
	27	dsl	—	Ingersoll 4	—	250
Clearfield County						
Delta Drlg Co	24	dsl	670	Emsco GC-500	500	8,500
	30	dsl	670	Emsco G-500	500	8,500
	34	gas-btne	800	Unit U-15	600	8,000
Fairman Drlg Co	1	gas-btne	500	Beth M-58	600	10,000
	2	gas-btne	500	"Oilwell" 66	600	9,000
Indiana County						
Lohmann-Johnson Drlg Co Inc	2	gas	500	"Oilwell" 76	750	10,000
Montgomery County						
C S Garber & Sons Inc	—	gas-gaso	—	—	32	2,000
	23	dsl	—	Reich	—	1,200
	24	dsl	—	Ingersoll	135	130
Somerset County						
Delta Drlg Co	10	dsl	560	Unit U-15	560	7,000

There's a Continental-Emsco Slush Pump rated for your rig..





From portable rigs to deep offshore installations, there's a Continental-Emsco Slush Pump that will give you the volume-and-pressure range to meet your drilling requirements. A wide selection of liner sizes allows you to step-up pressures or volumes *gradually*.. or *fast,* as drilling conditions dictate.

You'll find these pumps are big in performance, low-cost in operation, and that they give you *more horsepower per pound* than any other slush pump.

A strong, rigid, lightweight power end is the result of Continental-Emsco's *Fabriform Construction,* which uses steel plates and special shapes in place of a bulky, heavy, rough casting. This means lower transportation costs and easier field handling.

Lubrication is automatic, since all running parts are flood lubricated by a positive-splash system.. troublesome lubrication and grease fittings are eliminated.

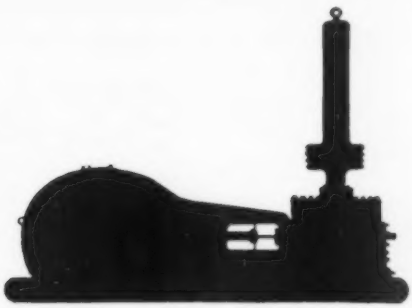
Typical of the simplified maintenance features of these pumps is their patented "exposed" liner construction. Here packing leaks can be spotted immediately.. long before damage can be.. or has been.. done.

..for Shallow Drilling D-175 and D-300

In the 175 and 300 horsepower range, these small pumps can produce the pressures and volumes to match the drilling range of all types of portable rigs .. and save on weight.

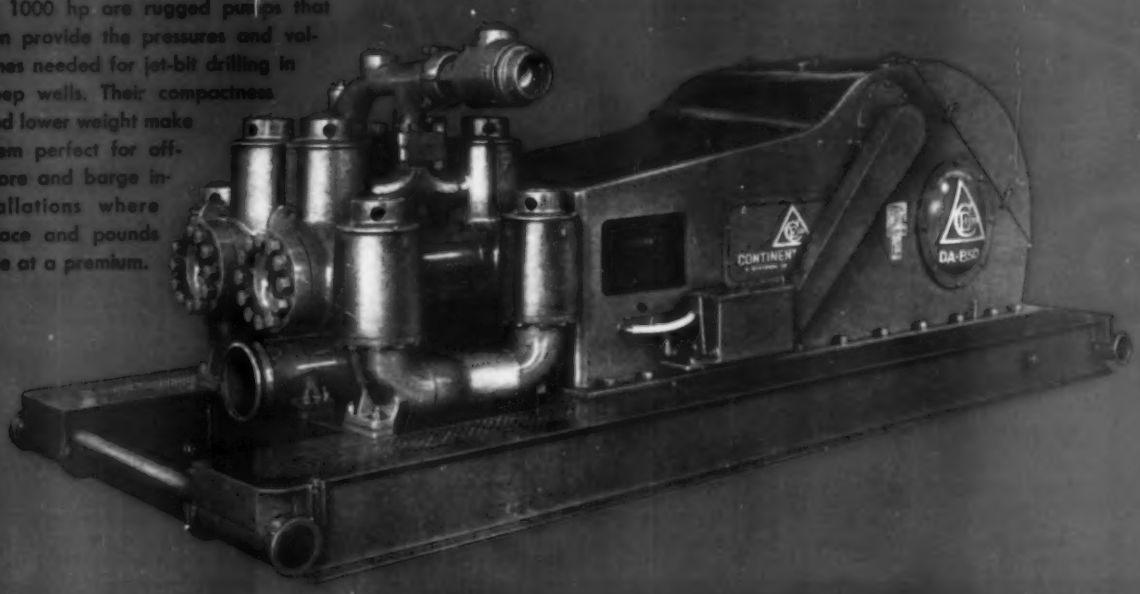
..for Medium-Deep Drilling DA-500 and D-700

These pumps are designed for rigs in the 600 to 1100 horsepower class. Here are pumps *sized* for medium-deep drilling. They are big in capacity .. lower in weight .. yet small enough to require a minimum amount of power.



..for Deep Drilling DA-850 and D-1000

The DA-850 at 850 hp and the D-1000 at 1000 hp are rugged pumps that can provide the pressures and volumes needed for jet-bit drilling in deep wells. Their compactness and lower weight make them perfect for offshore and barge installations where space and pounds are at a premium.



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Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Westmoreland County						
Delta Drlg Co	33	gas-btne	624	Natl 50-A	450	7,000
SOUTH DAKOTA						
Fall River County						
Branyan Drlg Co	1	dsl	600	Frnks 6000	600	6,000
TEXAS						
Anderson County						
Ace Drlg Co	3	gas	750	Natl 50-A	450	7,500
	4	gas	680	Emsco G-500	500	7,500
Harry Bass Drlg Co	109	stm	—	Emsco	—	14,000
Halbert Drlg Co	1	gas-btne	255	Wisn Torcair	285	5,500
LeCuno Oil Corp	5	dsl	250	Wisn Mogul 42	250	6,500
Trant Drlg Co	2	dsl	—	Ideco	—	12,000
Andrews County						
Arrow Drlg Co	17	gas	1260	Emsco 1250	—	14,000
Bickerstaff & Tibbets Drlg Co	5	dsl	300	Frnks SAL-5000	320	5,000
Big West Drlg Co	11	gas-btne	500	Unit U-20	900	14,000
Brantly Drlg Co Inc	6	gas	400	Natl 50	750	9,000
C B Drlg Co	4	gas	570	Emsco GB-350	570	3,000
Cactus Drlg Corp of Tex	1	gas-btne	1575	Natl 110	1575	15,000
	3	gas-btne	800	Natl 80-B	—	12,500
Capitan Drlg Co	2	gas	450	Emsco G-450	450	7,000
M J Delaney Co	19	gas-btne	600	Emsco J-1250	1200	15,000
	27	gas-btne	500	Beth 450	850	11,000
	31	gas-btne	450	Wisn Gnt Rdr	650	7,000
The Denver Co	1	gas	335	Natl T-20	300	5,500
Donnell Drlg Co	6	gas-btne	975	Beth MC-450	975	10,000
	9	gas-btne	1400	Beth MC-950	1400	15,000
	12	btne	400	Beth S45E	—	5,000
Fryer & Hanson Drlg Co	4	gas-btne	1150	"Oilwell" 76	1200	12,000
	11	gas-btne	1200	Beth M-58	1200	12,000
Great Western Drlg Co	17	gas-gaso	765	Unit U-914B	1260	15,000
	27	gas-gaso	853	Unit U-914A	1125	15,000
Helmerich & Payne Inc	39	gas	1100	"Oilwell" 96	1300	14,000
	41	gas	1200	Natl 110	1500	15,000
Hewgley Drlg Co	5	dsl	—	Emsco J-750	975	11,000
Keating Drlg Co	18	gas-gaso	—	—	1150	14,000
Carl B King Drlg of Tex	1	gas-gaso	1000	Natl 100	1000	13,500
King-Phillips Inc	4	gas	700	Beth S-45E	350	6,500
Julkirk Corp	2	gas-btne	900	Natl 75	900	11,000
Llano Drlg Co	2	gas	—	Natl 100	975	14,000
	3	gas	—	"Oilwell" 96	975	14,000
	4	gas	—	Natl 75	1050	12,000
McQueen & Stout Drlg Co	10	LPG	225	Crdwll RL	185	4,500
Milhoan Drlg Co	3	gas	900	Beth 450	—	10,000
Moran Oil Prod & Drlg Corp	3	gas	—	Unit U-15	800	8,500
Parker Drlg Co	4	gas	—	Natl L-100	1400	14,000
	16	gas	—	Natl L-100	1400	14,000
	41	gas	—	Natl L-100	1400	14,000
	47	gas	—	Natl L-100	1400	14,000
Penrod Drlg Co	1	gas-btne	—	—	1800	15,000
Robinson Bros Drlg Co	1	gas	800	Brwstr N-75	800	10,000
	3	gas	300	Brwstr N-55	500	6,500
	4	gas	300	Brwstr N-45	450	6,500
Sharp Drlg Co	20	gas	1350	Beth MC-950	1350	15,000
	32	gas	1200	Beth MC-450	1200	12,000
	36	gas	1350	Beth MC-950	1350	15,000
Western Serv Drlg Co Inc	1	gas-btne	340	Natl 50	360	5,000
Aransas County						
Layton Brown Drlg Co	Bge 4	dsl	1850	"Oilwell" 96	1100	16,000
J & E Drlg Co	7	gas-btne	700	Emsco 500	600	9,000
Archer County						
Akin & Dimock	2	dsl	300	Beth S-55	420	7,000
Fleeger Drlg Inc	5	dsl	360	Frnks	500	5,000
Louis Pitcock Drlg Co	1	gas-btne	225	Beth S-55	600	7,500
	2	gas-btne	225	Beth S-45	3250	4,000
R-G Drlg Co	1	gas-gaso	—	Wilson	650	6,500
Atascosa County						
Allen & Morris	7	dsl	500	Natl 75	900	10,000/5"
Armstrong & Horn Drlg Co	1	dsl	450	Brwstr N-4	—	7,000
Buzzini Drlg Co	8	gas-btne	1050	Wisn Titan	1210	13,000
	7	gas-btne	950	Wisn Atlas	930	11,000
Sutton Drlg Co	2	gas-gaso	—	—	125	2,500
Austin County						
Falcon Seaboard Drlg Co	18	dsl	700	Whind B-85	975	10,000
Bandera County						
Pool & Gerlich Drlg	D-1	gas	260	Unit U-34	300	5,000
Bastrop County						
Bay City Drlg Co Inc	3	gas-btne	560	"Oilwell" 66	560	10,800
Baylor County						
Abb Drlg Co	2	gas	200	Wisn Mogul	165	3,500
Meredith Drlg Co	1	btne	225	Wisn Super	145	3,500
W B Omohundro	4	btne	450	Wisn Atlas	—	6,000
Bee County						
Allen & Morris	3	stm	500	Emsco H-46M	1200	11,000/5"
Dan L Clark Drlg Co	5	gas-btne	1025	Brwstr N-7	800	8,500
Fitzpatrick Drlg Co	3	dsl	775	Brwstr N-7	700	8,500
General Well Drlg Inc	1	pwr	450	Unit U-34	200	5,500
Gilmour Drlg Co	2	gas	800	Natl 50	600	8,500
C G Glasscock Drlg Co	7	gas	800	Unit U-15	—	9,000
Hunt Drlg Co Inc	7	stm	1000+	Emsco UBLS	750	11,500
MIM Drlg Corp	1	dsl	500	Frnks SA-4500	300	5,000
Marvin S Ridgeway	—	gaso	—	Mayhew 1000	—	1,000/2⅛"
	—	gaso	—	Mayhew 600	—	600/2⅛"
Borden County						
Cactus Drlg Corp of Tex	6	gas-btne	300	Unit U-15	—	8,500
Empire Drlg Co	8	gas	500	Unit U-15	650	8,500
Falcon Seaboard Drlg Co	21	gas-btne	—	Unit U-15	600	8,500
John Grappe Drlg Co	3	gas-btne	1000	L C Moore	900	13,000
J E Jones Drlg Co	1	gas	500	"Oilwell" 66	630	8,000
Chas E Long Jr Inc	2	dsl	250	Emsco GA-500	520	10,000/3½"
Rheay & Reynolds Drlg Co	4	gas	350	Natl 50	1200	7,000
Sharp Drlg Co	37	gas	900	Beth MC-450	900	12,000
Warton Drlg Co	4	gas	700	Emsco J-750	1000	12,000
Bowie County						
H & S Drlg Co	2	gas-btne	1000	Brwstr N-95	1000	14,000
Brazoria County						
Holmes Drlg Co	2	stm	—	Emsco ECA	1000+	15,000
Hunt Drlg Co Inc	2	stm	750	Emsco H46M	1000+	11,000
Mac Drlg Co	12	stm	500	Natl 23-9-FED	1000+	20,000
Neal Drlg Co	1	gas	750	Emsco G-500	560	9,500
Robinson-Wehmeyer Drlg Co	1	gas-btne	450	Unit U-34	225	6,000
Brooks County						
Flournoy Drlg Co	4	gas-btne	175	Franks	185	3,500
Longhorn Drlg Corp	5	gas-btne	450	Unit U-15	675	9,000
Southland Drlg Co	4	dsl	700	Brwstr N-7	700	9,500
Stice Drlg Co	1	btne-gas	496	Unit U-15	—	7,500
Turnbull & Zoch Drlg Co	3	gas-btne	1125	Wisn Titan	1125	16,000
Well Drillers Inc	1	gas-gaso-btne	1140	Natl 75	870	9,500
Caldwell County						
Travis Drillers Inc	2	gas-btne	250	Brwstr H-3	165	3,000
Calhoun County						
Big "6" Drlg Co	2	dsl	550	Unit U-15	550	10,000
Bilbo-Redding Drlg Co Inc	8	gas-LPG	1600	Natl 110	—	12,000
Layton Brown Drlg Co	3	stm	—	—	1050	10,000
Coastal Marine Drlg & Constr Co	2	dsl-btne	925	Ideco 800	600	9,000
C G Glasscock Drlg Co	8	dsl	1200	Natl 75	—	12,000
Callahan County						
Red River Drlg Co	1	dsl	200	Wichtex R-4	165	3,000
Woodson Prod Co	2	gas	600	Unit U-15	900	8,500
	3	gas	300	Mayhew 3000	200	4,000
Carson County						
Cree Drlg Co Inc	2	gas-btne	255	Unit U-10	350	4,500
Keating Drlg Co	6	gas-gaso	—	—	450	5,000
Schafer Drlg Co	6	gas-gaso	200	Unit U-34	200	5,000
	7	gas-gaso	200	Ideco H-35	200	5,000
Cass County						
Butler-Johnson Inc	3	gas-btne	400	Brwstr N-45	400	7,000
	4	gas	500	Brwstr N-4	350	6,500
Chambers County						
B & G Well Maintenance	Bge 1	dsl	810	Natl 75	810	11,000
Bilbo-Redding Drlg Co Inc	Bge 6	dsl	1050	"Oilwell" 76	—	12,500
	Bge 7	dsl	550	"Oilwell" 64-B	—	7,500
Brewster-Bartle Drlg Co Inc	10	dsl	—	"Oilwell" 76	—	11,000
CBS Workover Co	3	gas-btne	300	Ideco H-30D	215	4,500
Clegg & Hunt	2	stm	—	Emsco H-54	—	11,000
Columbia Drlg Co	Bge 1	dsl	600	"Oilwell" 76	750	12,000
Hill Drlg Co	1	dsl-gas-btne	700	Unit U-35	370	8,000
Holmes Drlg Co	1	gas-gaso	—	Beth ML-450	1000	11,000
	7	gas-gaso	—	Beth MC-450	1000	11,000
Houston Oil Well Serv Co	2	dsl	—	Wisn Titan	1000	10,000
Kilroy Drlg Co	4	gas	450	Ideco 7-11	1200	12,000
Meadows & Walker Drlg Co	2	stm	1000	Alco BIW 12	1000+	12,000
	4	gas-btne	1455	"Oilwell" 76	1005	12,000
Meredith & Co	3	gas-gaso-btne	—	"Oilwell" 96	1150	13,000
Southworth & Wood Inc	1	gas-dsl	300	Crdwll TR-67	280	7,500
Cherokee County						
Maxwell Herring Drlg Corp	1	gas	300	Wisn Mogul	400	6,000
LeCuno Oil Corp	1	gas-LPG	705	Wisn Gnt Rdr	705	9,250
Clay County						
H O Grace Drlg Co	4	btne	—	—	—	7,500
Jennings Drlg Co	6	btne-gas	350	Brwstr	350	6,000
Jack L Story	5	gas-btne	450	Wisn Giant	450	7,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Cochran County						
Hissom Drlg Co	2	gas	400	Unit U-34	500	6,000
	3	gas	450	Beth S-60	450	6,500
Western Drlg Co Inc	9	btne	500	—	500	5,000
	13	dsl	600	Crdwll O	325	9,000
	14	dsl	375	Emsco 500	375	8,000
	18	btne	450	Crdwll O	225	8,000
Wes-Tex Drlg Co	3	btne	225	Crdwll B	326	6,500
Coke County						
Dual Drlg Co	2	dsl	400	Beth S-55	400	6,500
	3	gas	600	Beth M-58	600	10,000
Empire Drlg Co	5	gas	395	Unit U-15	570	8,000
McCutchen & Graham	3	btne	350	Wisn Spr Gnt	650	9,000
Coleman County						
Dixon Drlg Co	1	dsl-gas	260	Natl T-20	260	5,000
Maxwell Drlg Co	1	btne-gas	220	Brwstr N-4	220	5,000/3½
Moore & Moore Drlg Co	5	btne	175	Unit U-34	210	5,000
Tex-Mex Drlg Co	9	gas	400	Emsco 250	450	5,500
Colorado County						
Bilbo-Redding Drlg Co Inc	3	stm	1050	Emsco UBLS $4	1000+	12,500
	12	stm	900	Natl 34-8½	1000+	11,000
Buzzini Drlg Co	5	gas-btne	900	Wisn Gnt	712	10,000
Columbia Drlg Co	2	gas	600	Natl 75	—	11,500
Holmes Drlg Co	6	gas-gaso	—	Beth MC-450	700	10,000
Liberty Drlg Corp	1	gas-btne	750	Natl 75	—	10,000
Meadows & Walker Drlg Co	1	gas-btne	875	"Oilwell" 66	828	10,500
Chet Whaley Well Serv Co	1	gas-gaso-btne	225	Wisn Giant	225	5,500/3½"
Cooke County						
Alan Drlg Co	2	gas	350	Wisn Mogul	185	4,000
Brown & Martin Drlg Co	1	btne	230	Wisn Giant	215	5,500
	2	btne	150	Wilson	105	1,500
Felderhoff Bros Drlg Co	1	dsl	260	Wisn Mogul	220	4,700
Roy Guffey Drlg Co	3	gas-btne	430	Unit U-34	260	5,500
	5	gas-btne	430	Unit U-34	260	5,500
Gene McCutchin	5	gas	275	Wisn Giant	275	6,500
E W Moran Drlg Co	5	gas	370	Natl 50	650	7,500
Russell & Russell Drlg & Prod Co	1	gas-gaso-btne	275	Wisn Giant	180	4,500
	2	—	—	Wisn Mogul	—	—
	3	—	350	Wisn Mogul	350	5,000
Trachta Drlg Co	1	dsl	250	Wilson	185	3,000
Crane County						
Bickerstaff & Tibbets Drlg Co	4	gas	675	Unit U-15	675	9,000
Delta Drlg Co	4	gas-btne	800	Natl 100	800	12,000
Durham Drlg Co Inc	2	gas	500	Unit U-15	675	9,000
Gardner Bros Drlg Co Inc	6	gas-btne	500	Natl 75	700	10,500
	8	gas-btne	500	Unit U-15	675	7,000
Great Western Drlg Co	38	gas-gaso	320	Unit U-15	675	7,500
Guadalupe Drlg Co	1	gas-btne	700	Ideco M 1000	—	10,000
Helmerich & Payne Inc	42	gas	970	Natl 100	1000	13,000
Johnn Drlg Co	7	gas	185	Brwstr N-4	300	5,500
Keating Drlg Co	16	gas-gaso	—	—	450	6,500
Lee Drlg Co	1	gas-gaso	700	Natl 50	—	8,000
	2	gas-gaso	700	Natl 50	—	8,000
Milestone Drlg Co	100	dsl	550	Ideco H-525	600	7,500
Parker Drlg Co	39	gas	—	Natl L-100	1400	14,000
	59	gas	—	Natl 75	1000	11,000
Rowan Drlg Co Inc	22	gas-btne	600	Natl 50	766	7,000
Western Serv Drlg Co Inc	2	gas-btne	600	Natl 50-A	700	8,000
Wes-Tex Drlg Co	5	btne	276	Natl 50	588	8,500
Crockett County						
Bolin Oil Co & D H Bolin	1	gas	225	Natl T-12	145	3,500
Sam E Crump Drlg Co	1	gas	—	Unit U-15	650	6,500
Great Western Drlg Co	40	gas	450	Wisn Atlas	840	10,000
Hewgley Drlg Co	6	dsl	—	Emsco GB-500	650	9,000
Johnn Drlg Co	4	gas	375	Unit U-15	600	8,500
Pool & Gerlich Drlg	D-3	gas	350	Emsco G-250	300	6,000
Frank Raiborn Drlg Co	1	gas	225	Wisn Mogul	186	4,000
Texita Oil Co	1	dsl	320	Emsco GA-250	300	6,500
	3	dsl	260	Beth	300	5,000
Crosby County						
Smith & Breyer	4	gas	530	Frnks	530	9,500
Dallam County						
Rip C Underwood	1	gas-LPG	660	Unit U-15	660	9,500
Dawson County						
Harry Bass Drlg Co	101	gas	850	Emsco	570	9,000
	115	gas	1200	Emsco	1200	12,000
Kerr-McGee Oil Ind Inc	34	dsl	300	Frnks LTX-5000	300	5,000
B L McFarland Inc	12	gas	500	Brwstr N-55	—	8,000
Milhoan Drlg Co	6	gas	600	Unit U-15	—	8,000
Deaf Smith County						
Webster Drlg Co	3	gas-btne	750	Wisn Atlas	750	10,000
De Witt County						
Appell Petroleum Corp	2	dsl	520	Frnks SG-101	400	7,000
Brewster-Bartle Drlg Co Inc	4	gas		"Oilwell" 76		11,000
Don L Clark Drlg Co	2	gas-btne	1000	Emsco GC-500	500	7,500
Conroe Drlg Co	3	gas-btne	675	Unit U-15	675	9,500
Harkins & Co	3	gas-gaso	675	Unit U-15	675	10,000
Dimmit County						
Gilmour Drlg Co	3	gas	500	Wisn Gnt	300	6,000
Sutton Drlg Co	1	dsl			225	3,500
	3	dsl	300	Brwstr N-4	350	6,500
	4	dsl	350	Brwstr N-4	875	6,500
	6	dsl	121	Alamo	225	5,000/2⅛"
	9	—	—	—	—	—
Duval County						
Chiles Drlg Co	3	dsl	400	Ideco H-40-D	460	7,500
Davis & Bates Inc	1	dsl	375	Brwstr N-4	350	7,000
General Well Drlg Inc	8	gas-btne	500	Brwstr N-4	185	5,000
J E Hillier	1	dsl	400	Sullivan 300-A	200	4,000/3½"
A J Kuenstler Drlg Co	1	dsl	300	Wisn Giant	300	7,500
Ector County						
B B M Drlg Co	9	gas-btne	1300	Unit 30	1800	18,000
Robert M Bass Drlg Contr	3	gas-LPG	400	Wisn Gnt Roadair	600	8,500
Beckman Inc	1 (wo)	gas	185	Unit U-15	350	6,000
	2 (wo)	gas	185	Beth S-50	185	3,500
	11 (wo)	gas	300	Unit U-34	300	4,500
Bickerstaff & Tibbets Drlg Co	6	gas	675	Unit U-15	675	10,000
Brantly Drlg Co Inc	1	gas	365	Emsco 500	500	9,000
	2	gas	975	Emsco 800	1000	14,000
	3	gas	700	Brwstr N-75	750	11,000
	4	gas	375	Beth S-55	480	6,500
	5	gas	375	Emsco 250	250	4,000
C B Drlg Co	3	gas	650	Emsco 500	650	9,000
	5	dsl	325	Beth S-45-E	300	5,500
Choya Drlg Co Inc	5	gas-btne	460	Emsco GB-350	460	6,500
Davidson Drlg Co Inc	C	btne	660	Emsco GC-500	660	8,500
	D	btne	315	Wisn Mogul	600	7,500
M J Delaney Co	26	stm	—	Natl T-38	—	15,000
	30	gas-btne	500	Beth 1013	1200	15,000
Delta Drlg Co	36	gas-btne	900	Wisn Titan	900	15,000
Donnell Drlg Co	10	gas-btne	650	Beth M-58	650	10,000
Exploration Drlg Co	7	gas	1200	Natl 80-B	1350	13,000
	14	gas	800	Natl 75-CA	900	11,000
Lloyd R French Co	1	gas-btne	300	Unit U-10	300	4,500
	3	gas-btne	650	Natl 50	600	7,500
Gardner Bros Drlg Co Inc	5	gas-btne	500	Natl 75	675	9,000
	10	gas-btne	750	Natl 100	1050	12,500
	15	gas-btne	1000	"Oilwell" 96	1500	16,000
	16	gas-btne	1000	Natl 125	1400	15,000
	18	gas-btne	400	Natl 50	575	7,000
Highland Drlg Co	2	gas	325	Ideco H-35	375	5,600
Johnn Drlg Co	9	gas	375	Brwstr N-45	400	7,000
Carl B King Drlg Co of Tex	5	gas-gaso	1000	Natl 100	1000	13,500
King-Phillips Inc	1	gas-gaso	695	Natl 50	—	7,500
Lee Drlg Co	5	gas-gaso	1050	Natl 100	—	13,000
	6	gas-gaso	1050	"Oilwell" 76	—	13,000
M & J Inc	7	gas	269	Unit U-34	—	3,500
McQueen & Stout Drlg Co	9	LPG	225	Crdwll RL	185	4,500
Milhoan Drlg Co	7	gas	600	"Oilwell" 76	—	8,000
Norwood Drlg Co	2	gas-gaso	600	Wisn Atlas	900	10,500
	6	gas-gaso	650	Wisn Titan	900	12,000
Ormand Drlg Co Inc	1	gas	550	Wisn Giant	550	7,000
	2	gas	550	Wisn Giant	550	7,000
Parker Drlg Co	32	gas	—	Natl 50	700	9,000
	43	gas	—	"Oilwell" 96	1400	15,000
	58	gas	—	Natl L-100	1400	14,000
Rowan Drlg Co Inc	16	gas-btne	504	Natl 50	660	7,000
Sharp Drlg Co	34	gas	1350	Beth 1013	1350	16,000
Ray Smith Drlg Co	2	btne	350	Natl 50	600	7,500
Goal Tullous & Co	1	gas	500	Emsco J-750	1050	10,000
Warton Drlg Co	2	gas	600	Natl 50	700	8,500
Western Drlg Co Inc	15	dsl	375	Emsco 500	375	8,000
Fayette County						
Hamman Oil & Ref Co	6	dsl	250	Brwstr N-4	310	6,500
Fisher County						
General Geophysical Co	32	btne	—	—	500	7,500
Roy Guffey Drlg Co	2	gas-btne	520	Unit U-15	520	7,500
	4	gas-btne	560	Unit U-15	560	7,500
Herb Expl Co	—	gas-gaso	—	Failing 1500	—	1,500/2⅛"
Norwood Drlg Co	1	gas-gaso	350	Wisn Gnt Rdair	600	8,500
Rhodes Drlg Co	1	gas	300	Wisn Giant	450	5,500
Foard County						
E W Moran Drlg Co	2	gas	500	Wisn Giant	650	7,500
Fort Bend County						
CBS Workover Co	1	gas-btne	300	Ideco H-30D	215	4,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Freestone County						
Ace Drlg Co	2	gas	680	Emsco G-500	500	7,500
Frio County						
Pegg Bros Drlg Co	1	gas-btne	145	Brwstr	145	4,500/3½"
Gaines County						
B B M Drlg Co	2	gas-btne	1100	Emsco GB-800	1050	14,000/4"
	6	gas-btne	400	Emsco GB-500	650	10,000/3½
Harry Bass Drlg Co	112	gas	1200	Emsco	1200	12,000
Cactus Drlg Corp of Tex	5	gas-btne	700	Natl 75	700	10,000
Coroco Drlg Co	2	gas-gaso	650	"Oilwell" 96	900	15,000
Davidson Drlg Co Inc	A	gas-btne	1000	Emsco J-1250	1000	14,000
M J Delaney Co	29	gas-btne	500	Beth 450	750	11,000
Denver Drlg Corp	2	gas	550	Natl 50	550	8,500
Drlg & Expl Co of Del Inc	14	gas-elec	1100	Natl 34-10	1000	17,000
	24	gas	225	Wgnr Mrhse	400	5,000
Dual Drlg Co	4	gas	600	Beth 450	600	11,000
	6	gas	250	Emsco GA250T	300	5,000
John Grappe Drlg Co	2	gas-btne	720	Beth	—	13,000
O E Hall Drlg Co	2	gas	320	Unit U-15	700	8,000
	3	gas	320	Unit U-15	700	8,000
	5	gas	700	Unit U-40	1210	12,000
Hewgley Drlg Co	4	dsl	—	Emsco GA-500	650	8,500
Johnn Drlg Co	3	gas	650	Wisn Atlas	900	10,000
Carl B King Drlg Co of Tex	11	gas-gaso	900	Natl 75	900	11,000
Lowe Drlg Co	11	gas	1250	Natl 100	—	12,500
Moran Oil Prod & Drlg Corp	2	gas	—	Natl 75	750	10,000
Norwood Drlg Co	3	gas-gaso	1050	Wisn Titan	1050	12,500
Parker Drlg Co	53	gas	—	Natl 75	1000	11,000
Triad Drlg Co	4	gas-btne	400	Unit U-34	400	6,500
Galveston County						
Penrod Drlg Co	8	gas-btne	—	—	1230	10,000
	17	dsl	—	—	1464	14,000
	18	stm	—	—	—	15,000
Garza County						
Alan Drlg Co	1	gas	550	Wisn Giant	850	8,000
Hewgley Drlg Co	1	dsl	—	Emsco GA-500	650	8,500
McCutchen & Graham	1	btne	425	Wisn Spr Atlas	650	11,000
Smith & Breyer	2	gaso	—	Cooper	—	3,000
C D Turner Drlg Co	1	dsl	—	Brwstr N-4	—	5,500
Wes-Tex Drlg Co	6	btne	675	Unit U-15	675	9,500
Glasscock County						
Tri-Service Drlg Co	5	gas	825	"Oilwell" 76	825	10,000
Goliad County						
Falco Drlg Co	1	gas	750	Brwstr N-45	400	6,500
Field Drlg Co	4	dsl	520	Beth Breeze	260	5,500
Harkins & Co	6	gas-gaso	675	Unit U-15	675	9,500
J E Hillier	2	dsl	400	Ideco H-40	400	7,000
Hunt Drlg Co Inc	1	gas	625	Brwstr N-7	513	9,500
	3	gas	525	Emsco GB-350	443	8,500
Southland Drlg Co	1	dsl	750	Emsco GA-350	500	9,000
Yarborough Drlg Co	1	dsl	780	Wilson	600	9,000
	2	gas	290	Crdwll	200	5,000
Gray County						
Beckman Inc	18(wo)	gas	150	MIW P-42	200	10,000/2⅞"
Drlg & Expl Co of Del Inc	25	gas	225	Frnks 137/33 DTDX	400	5,000
Helmerich & Payne Inc	26	gas	500	Emsco GB-500	700	9,000
Hills & Hills Drlg Co	1	gas-btne	500	Emsco GB-350	—	6,500
Holt Bros Drlg Co	2	gas-btne	540	Ideco H-20	—	4,000

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HOUSTON, TEXAS

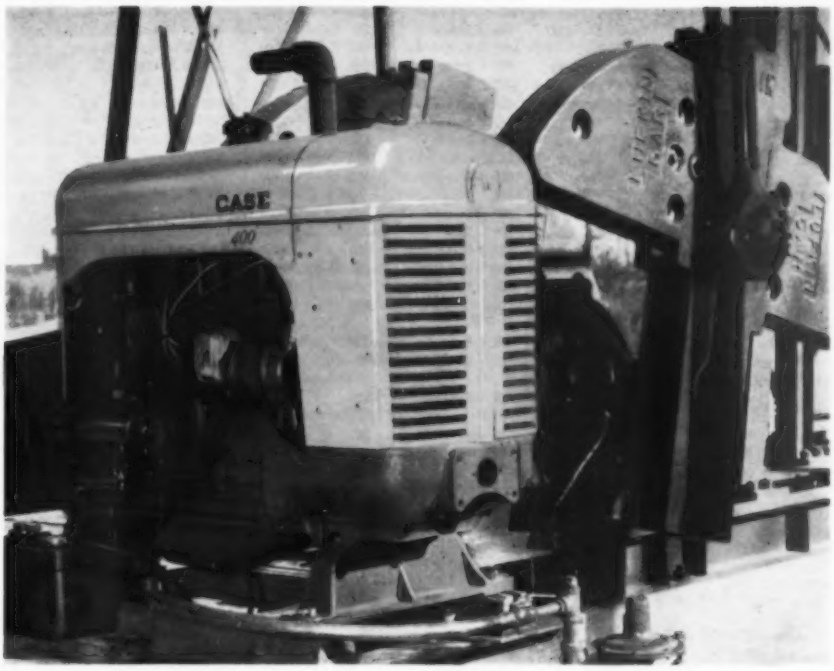
1069 San Jacinto Bldg.

B. M. SUTTON, *General Manager* CApitol 8-8535

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Latexo Drlg Co Inc	3	dsl	260	Brwstr N-4	260	5,000
Murphy & McKernan	1	dsl	390	Unit U-15	375	7,500
Service Drlg Co	1	dsl	320	Unit U-34	—	4,500
	6	dsl	320	Brwstr N-4	—	4,500
Gregg County						
Robert M Bass Drlg Contr	4	gas-LPG	300	Wisn Giant	300	5,500
	6	stm	1200	Emsco UBLS	1000+	12,500
Delta Drlg Co	7	stm	750	Emsco UB 54	1200	12,000
Jackson Oil Co	2	dsl	250	Spencer	200	6,000/3½"
Guadalupe County						
Bay City Drlg Co Inc	2	gas-btne	300	Unit U-34	300	5,000
Edgar Davis Drlg Co	12	gas-btne	650	Wisn Giant	675	10,000
Hansford County						
Arrow Drlg Co	20	gas	460	Emsco 350	—	7,000
Baker & Taylor Drlg Co	1	dsl	800	Unit U-15	800	8,500
	3	dsl	800	Unit U-15	800	8,500
Beckman Inc	19(wo)	—	180	MIW P-42	175	10,000
Graham-Michaelis Drlg Co	2	dsl	500	Unit U-15	500	7,000
Midwestern Drillers Inc	8	dsl	370	Unit U-15	750	8,500
Moran Bros Inc	1	gas	1050	Wisn Titan	1150	14,000
	6	gas	700	Wisn Giant	750	10,000
Reading & Bates Inc	2	gas-btne	900	Natl 75	1020	11,000
R W Rine Drlg Co	4	dsl	620	Brwstr N-75	750	9,500
Rowan Drlg Co Inc	10	gas-btne	1020	Beth 450	766	9,000
Urice Drlg Co	2	gas-btne	840	Emsco GA-500	840	9,000
Hardin County						
Bilbo-Redding Drlg Co Inc	5	gas-LPG	900	Beth 450	—	11,000
Owen Drlg Co	8	dsl	1040	Natl 80	1040	9,500
Timberland Expl Co	2	gas-btne	1100	"Oilwell" 76	1200	11,500
Harris County						
Bay City Drlg Co Inc	1	gas-btne	430	"Oilwell" 52-T	430	6,500
Big "6" Drlg Co	3	gas-btne	500	Crdwll Tlrg	500	6,000
Comet Drlg Co	3	stm	900	Ideco Jr Gnt	—	10,000
Edwards & Bissett Inc	6	gas-btne	600	Ideco H-40D	500	7,000
Housh Drlg Co	1	stm	900+	Natl	1000+	12,000
	2	stm	900+	Natl	1000+	12,000
	3	stm	800+	Emsco UBLS	800+	10,000
	5	stm	600+	Emsco UBLS	600+	8,000
	6	stm	600+	Emsco UBLS	600+	8,000
	7	stm	600+	Emsco UBLS	600+	8,000
	8	stm	600+	Emsco UBLS	600+	8,000
	9	gas	435	Unit U-34	300	5,000
	10	gas-btne	1100	Ideco H-750	900	10,000
Houston Oil Well Serv Co	4	gas-btne	—	Ideco M-10,000	855	10,000
Liberty Drlg Corp	2	gas-btne	675	Unit U-15	—	9,000
Lusk Drlg Co	14	gas	600	Crdwll Trlr	380	6 500
Mac Drlg Co	7	stm	500	Natl 34-26	5000	10,000
Lubie Martin Drlg Co	1	gas	300	Brwstr N-4	400	6,000
Miller Bros & Bowling	2	gas-btne	800	Emsco G-450	—	8,500
Timberland Expl Co	3	gas-btne	800	Unit U-15	700	9,000
Triton Drlg Co Inc	8	gas	800	Unit U-15	800	10,000/4"
W L B Drlg Co	1	gas-gaso-btne	350	Brwstr N-35	165	3,500
Carnes W Weaver Drlg Co	5	gas-btne	465	Unit U-34	—	5,000
Harrison County						
Barnwell Drlg Co Inc	11	dsl	800	Wisn Roadair	600	12,000
	45	dsl	800	Brwstr N-45	380	8,000
LeCuno Oil Corp	4	gas-LPG	1050	Wisn Titan	1050	13,500
Penrod Drlg Co	7	dsl	—	—	730	9,000
J C Trahan Drlg Contr Inc	1	gas	740	Unit U-15	600	9,500
Hartley County						
Wagner & Wyant Drlg Co Inc	1	dsl	300	Unit U-15	450	8,000
Haskell County						
Ellis & Gray	4	dsl	300	Unit U-34	300	5,000
Lamar H Moore Drlg Co	2	btne	250	Wisn Giant	480	7,000
Tex-Mex Drlg Co	7	gas	—	Emsco GB-350	—	7,000
Thomas & Billups Drlg Co	2	btne	450	Emsco 300	450	6,000
West Central Drlg Co	7	gaso-btne	225	Wisn Giant	250	5,000
Hemphill County						
Baker & Taylor Drlg Co	4	gas-btne	750	Emsco G-500	750	9,500
	5	gas-btne	1650	Natl 110	1650	15,000
	7	gas-btne	1000	Natl 55	1000	10,500
	8	gas-btne	750	Emsco G-500	750	9,000
Henderson County						
M J Delaney Co	21	gas-btne	500	Wisn Titan	650	9,500
Hidalgo County						
Clark Fuel Prod Co	1	dsl	260	Natl T-8-S	140	2,500
Conroe Drlg Co	2	gas-btne	675	Unit U-15	675	9,500
Field Drlg Co	2	dsl	1500	Unit U-15	1200	9,000
Fitzpatrick Drlg Co	1	stm	800+	Ideco	1000+	12,000
	2	gas	950	Unit U-40	900	10,000
Frio Drlg Inc	3	gas-btne	800	Brwstr N-55	800	10,500
Harrell Drlg Co	3	gas	700	Unit U-15	700	8,500
Holmes Drlg Co	3	gas-gaso	—	Natl 110	1500	16,000

CASE® OILFIELD ENGINES

cut costs three ways



Job records prove that Case oilfield engines carry their rated loads for longer periods, with greater fuel economy, and lower maintenance cost than any other engines in their power class. In fact, many Case engines are *still pumping efficiently after 10 years of continuous service without major overhaul.* Here's why:

1. Longer operating life

Case engine-blocks are heavily ribbed, both inside and out, to give maximum strength and rigidity . . . keep bearings in proper alignment . . . and to prevent excessive wear under heavy loads. Dynamically balanced forged steel crankshafts have big bearings on each side of each connecting rod for smooth, vibration-free operation.

2. Greater fuel economy

Exclusive Case spark-ignition "Powerdyne" and diesel "Powercel" combustion chambers provide complete, clean fuel combustion with uniform "push" on cylinders. Overhead valve design, combined with Case-built *weather-sealed* magneto and positive cooling also help save fuel.

3. Easier maintenance

Wet-type cylinder sleeves and multiple cylinder heads insure quick, easy replacement after long service without moving engine from its base. Main bearing inserts can also be easily replaced without removing crankshaft.

CHOICE OF SIZES AND FUELS

Dependable Case oilfield engines are available in the following sizes — for diesel, gasoline, natural gas, or LP gas:

- **600 Series — 106 Max. Int. HP @ 1800 RPM**
- **400 Series — 70 Max. Int. HP @ 1800 RPM**

Smaller size engines are also available starting at 32 Max. Int. HP. (Note: above figures are for gasoline-powered units; RPM's shown are max. recommended.)

For *new* oilwell pumping installations, or for *re-powering*, you'll get more economical power with Case oilfield engines. Remember, too, you can depend on *fast parts service anywhere, any time* — through a world-wide network of Case engine dealers and factory-owned branches — one near you.

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Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Hugh Kirkpatrick Inc	1	gas	696	TIW 5	712	8,000
	2	gas	1080	Natl 55-A	600	10,000
Rhodes & Hicks Drlg Corp	1	gas-btne	370	Frnks 137	200	5,500
Stewart & Gouger Drlg Co	3	pwr	1000	Emsco GB-500	750	10,000
Turnbull & Zoch Drlg Co	5	gas-btne	850	Unit U-15	850	9,500
Viking Drlg Co	2	dsl	475	Natl 50-A	500	8,500
	3	gas-gaso	500	Unit U-15	600	9,000
Well Drillers Inc	2	gas-gaso-btne	1821	Ideco 7-11 Spr	1446	14,000
	4	stm	1000+	Alco BIW 12	1690	15,000
Hockley County						
Arrow Drlg Co	22	dsl	1200	Emsco 1000	—	14,000
John Grappe Drlg Co	1	gas-btne	520	Beth	—	8,500
Great Western Drlg Co	35	dsl	300	Unit U-15	760	7,500
	37	gas-gaso	700	Unit U-40	1200	10,000
Lowe Drlg Co	5	gas	750	Natl 75	—	10,000
Robinson Bros Drlg Co	2	gas	800	Brwstr N-75	800	10,000
Hopkins County						
B G Byars Power Drlg Co	3	dsl	400	Emsco G-300	300	5,500
Delta Drlg Co	15	gas-btne	530	Unit U-15	600	8,000
Howard County						
Bolin Oil Co & D H Bolin	7	gas	225	Beth S-50	185	4,500
Capitan Drlg Co	1	gas	700	Emsco GC-500	700	10,000
Travis Drlrs Inc	1	gas-btne	325	Natl T-20	245	5,000
C D Turner Drlg Co	2	btne	180	Wisn Mogul	180	4,500
Hutchinson County						
Cree Drlg Co Inc	3	gas-btne	225	Wisn Giant	300	5,000
J R McGill	1	gas-gaso	—	Emsco	570	7,000
Service Drlg Co	2	LPG	300	Unit U-34	—	4,500
	10	LPG	250	Unit U-34	—	4,000
Wagner & Wyant Drlg Co Inc	3	dsl	175	Unit U-34	300	5,000
Jack County						
Bolin Oil Co & D H Bolin	9	gas	185	Wisn Super	145	4,000
Jim Fish Drlg Co	1	gas	165	Wilson	140	4,000
Ward Drlg Co	2	btne	300	Wisn Giant	600	5,000
Jackson County						
Harry T Bryant Drlg Co Ltd	2	gas-btne	700	—	600	8,000
Field Drlg Co	1	dsl	1040	Natl 50-A	520	8,500
Liberty Drlg Corp	3	gas-btne	1000	Natl 100	—	13,000
Jasper County						
Southland Drlg Co	3	gas-btne	835	Crdwll O	675	10,000/5"
Jefferson County						
Admiral Drlg Co Inc	B	gas-LPG	450	Crdwll O	362	9,500
Clegg & Hunt	3	dsl	—	Wisn Titan 56	800	11,500
	7	dsl	—	Natl 75	880	11,000
	9	btne-gas	—	Natl 50-A	—	9,500
	10	btne-gas	—	Natl 50-A	—	9,500
Henderson Drlg Corp	4	gas-btne	1000	Natl B-80	1000	12,500
Kilroy Drlg Co	3	gas	450	Brwstr N-45	1200	12,000
Meredith & Co	1	gas-gaso-btne	—	Emsco G-500	680	9,500
	4	gas-gaso-btne	—	Brwstr N-45	850	11,500
Jim Hogg County						
Falco Drlg Co	2	gas	600	Wisn Giant	650	8,000
Jim Wells County						
Chiles Drlg Co	2	dsl	300	Ideco H-40	300	6,000
General Well Drlg Inc	3	gas-btne	425	Beth	183	5,000
	7	dsl	650	Crdwll	300	6,500
Gilmour Drlg Co	1	gas	800	Unit U-15	600	8,500
Chet Whaley Well Serv Co	2	gas-gaso-btne	225	Wisn Giant	275	5,500/3½"
Jones County						
Black Drlg Co	1	dsl	275	Frnks	250	4,000/3½"
Cooper Drlg Co	5	gas-btne	600	Wisn Giant	600	7,500
Dixon Drlg Co	4	dsl-gas	200	Natl T-12	200	4,000
Drill Well Oil Co	1	btne	185	Wisn Super	—	4,000
Fryer & Hanson Drlg Co	10	gas-btne	225	Unit U-34	275	4,500
Hack Drlg Co	1	btne	—	Unit U-15	412	8,500
	4	btne	—	—	161	2,500
Sojourner Drlg Corp	4	btne	225	Unit U-34	—	4,500
Irish Drlg Co Inc	3	btne	285	Wisn Mogul	—	4,000
Kaufman County						
Walters Drlg Co Inc	14	gas	—	Mayhew 1000	150	400/2⅛"
Kenedy County						
Del Mar Drlg Co	1	stm	800+	Alco BIW 12	1000	11,000
Fitzpatrick Drlg Co	4	gas	1050	Beth Tornado	1000	13,000
Kent County						
Dugger & Herring Drlg Co	2	gas-btne	500	Unit U-15	600	8,500
King County						
West Central Drlg Co	5	gaso-btne	325	Unit U-15	600	7,500
Kleberg County						
Conroe Drlg Co	1	stm	1000	Natl 34-10FE	1000	15,000
Flournoy Drlg Co	2	gas-btne	300	Wisn Giant	185	4,500
Stewart & Gouger Drlg Co	4	pwr	—	Natl 110	1100	15,000
Knox County						
Abb Drlg Co	1	gas	185	Wisn Super	145	2,500
D-D Drlg Co	1	btne	145	Wilson	—	2,500
T V Gorman Drlg Contr	2	dsl	300	Wisn 38 Torcair	300	4,500
E W Moran Drlg Co	4	gas	300	Unit U-15	650	7,500
Smith & Broyer	3	btne-dsl	355	Spencer	355	4,250
Lamb County						
Frisbie Drlg Co	1	btne	450	Unit U-15	450	8,000/3½"
Livermore Drlg Co	1	gas	870	Wisn Titan	975	12,500
	3	gas	600	Natl 75	680	10,000
Western Drlg Co Inc	6	dsl	600	—	290	6,000
	17	btne	440	Crdwll L	145	4,000
Lavaca County						
Admiral Drlg Co Inc	G	dsl	650	Beth M-58	300	9,500
Edwards & Bissett Inc	3	gas-btne	1100	Brwstr N-75	800	10,500
Schimmel Drlg Co	1	dsl	350	Wisn Gnt Torcair	450	7,500
Symons Drlg Co	U-15	gas	500	Unit U-15	650	9,500
W P Taylor Drlg Co	3	gas	—	Natl	900	11,000
Liberty County						
Admiral Drlg Co Inc	F	gas-LPG	700	Wisn Giant	350	8,500
B B M Drlg Co	3	stm	—	Emsco UBLS-54-10	—	14,000
Harry T Bryant Drlg Co Ltd	3	gas-btne	700	TIW 5	600	8,000
Edwards & Bissett Inc	1	gas-btne	800	Wisn Gnt Roadair	800	8,500
Houston Oil Well Serv Co	5	stm	1000+	Natl	1000+	12,000
Hunt Drlg Co Inc	5	gas	1200	Beth MC-650	1200	14,000
Prince Marine Drlg & Expl Co	3	gas	900	"Oilwell" 66	900	10,500
Carnes W Weaver Drlg Co	1	gas-btne	700	"Oilwell"	—	10,500
Lipscomb County						
Cree Drlg Co Inc	1	gas-btne	500	Unit U-15	750	8,500
	5	gas-btne	825	Unit U-40	975	14,000
Moran Bros Inc	2	gas	700	Emsco GA-500	750	10,000
	4	gas	1100	Wisn Titan	1300	15,000
Rowan Drlg Co Inc	9	gas-btne	900	Natl 75	1110	11,000
	31	gas-btne	900	Natl 75	1149	11,000
Triad Drlg Co	6	gas-btne	600	Beth M-58	600	10,000
Webster Drlg Co	8	gas-btne	1050	Ideco 7-11	1050	12,000
Live Oak County						
Field Drlg Co	3	dsl	1110	Emsco 500	520	8,500
J & C Drlg Co	5	dsl	800	Wisn 54	800	12,000
Longhorn Drlg Corp	3	stm	—	Emsco H-40	—	10,000
Miller Bros & Bowling	3	gas-btne	850	Emsco GC-500	—	9,000
Stewart & Gouger Drlg Co	5	pwr	1000	Ideco 7-11	1000	12,000
Loving County						
Calco Drlg Co	6	dsl	300	Beth S-45E	250	5,500
Leatherwood Drlg Co	1	gas	600	Ideco 750	—	10,000
McQueen & Stout Drlg Co	11	LPG	225	Crdwll RL	185	4,500
Lubbock County						
Western Drlg Co Inc	21	btne	650	Natl 100	325	10,000
Madison County						
Trant Drlg Co	1	dsl	—	Unit U-15	—	9,000
Marion County						
Butler-Johnson Inc	2	gas-btne	450	Brwstr N-55	450	8,000
Crow Greyhound Drlg Co Inc	1	dsl	300	Brwstr N-4	280	5,500
Milton Crow Inc	4	gas	900	Brwstr N-75	600	10,000
Glenn Drlg Co	1	dsl	200	Unit U-10	300	5,000
Halbert Drlg Co	2	gas-btne	285	Wisn Roadair	445	6,500
Tex-Mex Drlg Co	10	gas	—	Emsco GB-500	—	9,000
Martin County						
B B M Drlg Co	10	gas-btne	200	Emsco GA-500	450	7,000/3½"
Falcon Seaboard Drlg Co	Z-10	dsl	—	Beth 950	1350	16,000
Sharp Drlg Co	40	gas	1350	Beth Tornado	1350	14,000
Matagorda County						
Bass Drlg Co	1	gas-gaso-btne	675	Unit U-15	—	10,000
	2	gas-gaso-btne	675	Unit U-15	—	10,000
Bilbo-Redding Drlg Co Inc	9	stm	1050	Emsco ECC	1000+	15,000
Columbia Drlg Co	5	dsl	400	Unit U-15	—	8,500
C G Glasscock Drlg Co	10	dsl	750	Natl 50	—	9,000
Henderson Drlg Corp	3	gas-btne	700	Natl 75	750	11,000
Meadows & Walker Drlg Co	3	gas-btne	900	Unit U-15	675	8,500
Miller Bros & Bowling	1	gas-btne	495	Emsco G-300	—	5,500
Turnbull & Zoch Drlg Co	1	stm	1600	Emsco	1000+	16,000
McMullen County						
Allen & Morris	2	stm	400	Alco BIW 11	600	12,000/5"
	4	gas	400	Natl 50	400	8,500/5"
	5	pwr	1100	"Oilwell" 76	780	12,000
	8	stm	500	Emsco UBLS-54	1200	12,500/5"
Buzzini Drlg Co	1	gas-btne	150	TIW	150	3,000
Flournoy Drlg Co	3	gas-btne	353	Brwstr N-45	320	6,500
Longhorn Drlg Corp	4	gas-btne	450	Unit U-15	675	9,000
Pegg Bros Drlg Co	2	gas-btne	110	—	110	3,000/3½"
Sutton Drlg Co	7	dsl	121	Alamo	225	5,000
Midland County						
B B M Drlg Co	1	gas-btne	950	Emsco GB-800	1050	14,000/4"
	4	gas-btne	400	Natl 50	600	8,500/3½"
	8	gas-btne	450	Beth M-58	650	9,000

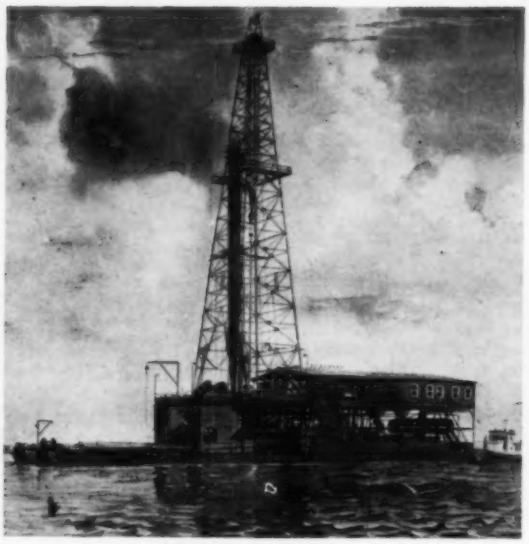
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Big West Drlg Co	17	gas-btne	600	Wlsn Titan	900	13,000
Brantly Drlg Co Inc	8	gas	675	Beth 450	870	11,500
Clark Dale Drlg Co Inc	2	gas	—	Natl 50	600	8,500
Delta Drlg Co	3	gas-btne	900	Natl 100	800	12,000
Empire Drlg Co	3	gas	500	Brwstr N-75	975	12,000
Exploration Drlg Co	12	dsl	1200	Natl 125	1350	16,000
Falcon Seaboard Drlg Co	Z-3	gas-btne	—	Beth 950	1600	18,000
	Z-11	gas-btne	—	Beth 950	1020	16,000
Lloyd R French Co	2	gas-btne	675	Unit U-15	600	7,500
Great Western Drlg Co	21	gas-gaso	840	Unit U-914A	1260	15,000
	34	dsl	495	Unit U-40	1200	10,000
Helmerich & Payne Inc	9	gas	1200	"Oilwell" 96	1100	14,000
J E Jones Drlg Co	3	gas	1070	"Oilwell" 76	1035	12,000
B L McFarland Inc	9	gas	400	Crdwll RL	—	4,500
Norwood Drlg Co	7	gas-gaso	650	Wilson	600	9,500
Rowan Drlg Co Inc	25	gas-btne	1260	Natl 100	1680	14,000
Goal Tullous & Co	2	gas	600	Emsco J-750	1050	10,000
Mitchell County						
Lowe Drlg Co	6	gas	500	Unit U-15	—	7,500
Montague County						
Hale Bros Drlg Co	2	gas	—	Wlsn Giant	—	6,500
Gene McCutchin	8	gas	550	Natl 50	550	8,000
E W Moran Drlg Co	1	gas	500	Unit U-15	560	7,500
Orm Drlg Co	1	dsl	600	Unit U-15	—	9,500
Dwight M Ross Drlg Co	1	gas-btne	300	Wlsn Atlas	660	7,500
Ward Drlg Co	1	dsl	350	Wlsn Titan	750	6,500
Montgomery County						
Bilbo-Redding Drlg Co Inc	1	dsl	750	Whind 65	550	9,500
	4	gas-LPG	580	Wlsn Giant	—	8,000
	11	gas-LPG	325	Unit U-34D	290	5,500
Harry T Bryant Drlg Co Ltd	4	gas-btne	900	Natl 75	900	12,000
Foretich Drlg Co Inc	1	btne-gas	745	Unit U-35	450	8,000
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	5,000
Moore County						
Cree Drlg Co Inc	7	gas-btne	185	Emsco 250	300	4,500
Latexo Drlg Co Inc	2	gas-btne	370	Unit U-34	370	6,500
Morris County						
Gibson Drlg Co	4	gas-btne	226	Wlsn Mogul	225	4,500
Navarro County						
Smith & Breyer	1	btne	146	Mayhew	135	2,500
Stroube Drlg Co	—	btne	175	Mayhew	175	1,650/2½"
Nolan County						
C B Drlg Co	1	gas	450	Emsco GB-350	450	8,000
Choya Drlg Co	1	gas	500	Emsco GB-500	550	8,500
Coroco Drlg Co	6	gas-gaso	400	"Oilwell" 66	500	9,000
M J Delaney Co	24	gas-btne	500	Beth M-58	600	9,500
Denver Drlg Corp	4	gas	440	Natl 50	440	8,000
Empire Drlg Co	2	gas	500	Brwstr N-7	675	9,500
Roy Guffey Drlg Co	6	gas-btne	560	Unit U-15	560	7,500
Highland Drlg Co	1	gas	—	Natl 50	550	8,200
Layton & Newell Drlg Co	1	gas-btne	500	Unit U-15	600	8,000
Lamar H Moore Drlg Co	3	btne	250	Unit U-15	552	8,000
Rhodes & Hicks Drlg Corp	2	btne	370	Natl T-32	370	6,500
St John Drlg Co	1	gas	400	Wlsn Gnt Rd	700	8,500
Sojourner Drlg Corp	3	dsl	550	Unit U-15	—	7,500
Nueces County						
Appell Petroleum Corp	3	gas-gaso	510	Brwstr N-4	225	5,500
Layton Brown Drlg Co	Bge 2	dsl	—	—	800	10,000
Camden Drlg Co	2	dsl	600	Natl T-32	300	7,500
Del Mar Drlg Co	6	gas-btne	—	Wlsn Gnt	750	9,500
C G Glasscock Drlg Co	9	dsl	400	Natl T-20	—	6,000
Harkins & Co	1	gas-gaso	555	Unit U-15	555	8,500
J & C Drlg Co	3	gas-btne	450	Natl 80	450	7,500
	6	gas-btne	450	Natl 50	450	7,500
Harold L Strader Drlg Co	Bge 401	gas-gaso-btne	—	Brwstr N-4	—	5,500
Viking Drlg Co	4	gas-gaso	450	Unit U-10	500	8,500
Ochiltree County						
Arrow Drlg Co	9	gas	560	Emsco 500	—	8,000
Baker & Taylor Drlg Co	2	dsl	800	Unit U-15	800	8,500
Cree Drlg Co Inc	4	gas-btne	350	Emsco GA-500	600	9,000
	9	gas-btne	350	Unit U-15	650	8,500
Forse Drlg Co	5	btne	350	"Oilwell" 52-T	426	6,000
Keating Drlg Co	13	gas-gaso	—	—	1000	12,000
Rowan Drlg Co Inc	2	gas-btne	840	Natl 75	1120	11,000
Wagner & Wyant Drlg Co Inc	2	dsl	300	Unit U-15	675	8,000
Oldham County						
Lynn Drlg Co	3	gas-btne	1000	Natl 75	1000	11,500
	5	gas-btne	725	Natl 75	900	10,500
Wagner & Wyant Drlg Co Inc	4	gas-btne	500	Unit U-15	700	9,000
Orange County						
Timberland Expl Co	1	gas-btne	850	"Oilwell" 76	1050	10,500
Palo Pinto County						
E & H Drlg Co	1	gas	550	Unit U-15	550	7,500
Panola County						
Delta Drlg Co	22	gas-btne	530	Unit U-15	600	8,000
South States Drlg Co	3	dsl	330	Emsco GB-350	520	8,000/4"
Tex-Mex Drlg Co	8	stm	—	—	1000+	9,000
Wise Drlg Account	2	dsl	550	Beth MC-450	550	9,000
Parker County						
Hunter Bros	2	gas-btne	700	Wlsn Roadair	700	8,500
	3	gas-btne	400	Wlsn Mogul	200	4,500
Leatherwood Drlg Co	4	gas	450	Crdwll	450	6,000
R-G Drlg Co	2	gas-gaso	—	Wlsn	650	8,000
Pecos County						
Blount Drlg Corp	1	gas-btne	700	Wlsn Gnt Rdair	700	8,500
	2	gas-btne	675	Unit U-15	675	8,000
Gardner Bros Drlg Co Inc	11	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	2	gas-gaso	500	Wlsn Gnt Rdmstr	840	9,000
	9	gas	1053	Unit U-20	1600	16,000
	44	dsl-elec	1400	Unit U-1220	3000	25,000
Keating Drlg Co	8	gas-gaso	—	—	650	8,500
Kerr-McGee Oil Ind Inc	3	gas	800	Natl 75	832	11,500
Parker Drlg Co	44	gas	—	Natl L-125	1400	15,000
	26	gas-elec	—	Natl L-10½ FE	2000	20,000
Penrod Drlg Co	12	gas-btne	—	—	1425	14,000
	32	dsl	—	—	1460	15,000
Pool & Gerlich Drlg	D-2	gas	260	Unit U-34	300	5,000
Rowan Drlg Co Inc	28	gas-btne	1300	Natl 125	1530	15,000
	29	gas-btne	1200	Natl 100	1480	14,000
Potter County						
Urica Drlg Co	5	gas-btne	560	Wlsn Giant	560	8,000
Reagan County						
Dual Drlg Co	1	gas	600	Wlsn Giant	600	9,000
Pool & Gerlich Drlg	D-5	gas	260	Natl T-12	200	3,500
Tri-Service Drlg Co	2	gas	675	"Oilwell" 66	675	8,500
Reeves County						
Hissom Drlg Co	4	gas	400	Unit U-34	350	5,000
Western Serv Drlg Co Inc	7	gas-btne	600	Natl 50	700	7,000
Refugio County						
Flournoy Drlg Co	1	gas-btne	225	Ideco HD-35	320	5,000
Burdette Graham	1	gas-btne	738	Beth M-58	700	9,500
Harkins & Co	4	gas-gaso	700	Wlsn Giant	700	9,500
J & C Drlg Co	2	stm	600+	Emsco H-46	700+	9,000
	8	gas-btne	800	Beth 650	800	12,000
Roberts County						
Schafer Drlg Co	9	gas-gaso	300	Ideco H-35	300	7,500
Webster Drlg Co	9	gas-btne	—	Natl 100	1110	14,000
Robertson County						
Bay City Drlg Co Inc	4	gas-btne	420	Brwstr N-45	420	7,500
Runnels County						
Cooper Drlg Co	3	gas-btne	450	Natl 50	450	6,500
Johnn Drlg Co	2	gas	375	Unit U-15	400	7,500
	5	gas	375	Unit U-15	600	8,500
Moore & Moore Drlg Co	4	btne	175	Unit U-34	210	5,000
Lamar H Moore Drlg Co	1	btne	173	Crdwll RL	210	5,000
Paine Drlg Co	5	btne	450	Wlsn Giant	450	7,000
Pool & Gerlich Drlg	D-4	gas	260	Natl T-20	400	6,000
Robinson Drlg Co	4	gas-btne	155	Crdwll S	140	4,500/3½"
West Central Drlg Co	8	gaso-btne	325	Wlsn Roadair	975	10,000
Rusk County						
Gibson Drlg Co	1	gas-btne	275	Wlsn Mogul 42	265	5,000
	3	gas-btne	300	Wlsn Giant	275	6,000
	5	gas-btne	275	Wlsn Giant	275	6,000
F E Hargraves & Sons Drlg Co	4	dsl	275	Brwstr N-A	300	6,000/3½"
Maxwell Herring Drlg Corp	2	gas	700	Wlsn Gnt Rdair	700	10,500
Ruhl Drlg Co Inc	1	—	475	Brwstr N-7	625	8,500
South States Drlg Co	4	dsl	275	Emsco GA-350	480	7,000/4"
Tex-Mex Drlg Co	6	gas-btne	1200	Wlsn Titan	1200	13,000
J C Trahan Drlg Contr Inc	2	gas	600	Unit U-15	600	9,500
Sabine County						
Maxwell Herring Drlg Corp	4	gas	600	Wlsn Gnt Rdair	600	8,000
San Jacinto County						
Big "6" Drlg Co	5	gas-btne	500	Wlsn Gnt	500	9,000
Rowan Drlg Co Inc	4	gas-btne	900	Natl 75	1149	11,000
San Patricio County						
Chiles Drlg Co	1	dsl	600	Brwstr N-7	600	8,500
Davis & Bates Inc	2	btne	800	Brwstr N-7	800	9,500
Frio Drlg Inc	2	dsl	400	Unit U-15	400	6,500
Hunt Drlg Co Inc	4	gas	485	Emsco GB-250	306	7,000
Southland Drlg Co	2	gas-btne	700	Brwstr N-55	700	9,000/5"
Turnbull & Zoch Drlg Co	2	stm	1600	Ideco	1000+	14,000
Schleicher County						
Great Western Drlg Co	5	gas-gaso	500	Unit U-15	750	7,500
Tucker Drlg Co	1	gas	600	Brwstr N-55	—	9,500
	2	gas	425	Brwstr N-4	—	6,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Scurry County						
Cactus Drlg Corp of Tex	8	gas-btne	675	Brwstr N-7	675	9,000
Calco Drlg Co	1	gas-btne	225	Mayhew 3000	200	3,500
Dearing Inc	3	gas-btne	—	Wichtex	—	3,000
	4	gas-btne	—	Wilson	—	4,000
Dual Drlg Co	5	gas	400	Emsco GA-500	400	7,000
General Geophysical Co	31	dsl	—	—	500	7,500
Dave Harlin Drlg Co	1	btne	—	Beth	—	12,000/2⅞"
Chas E Long Jr Inc	3	dsl	400	Emsco GA-500	520	10,000/3½"
McQueen & Stout Drlg Co	12	LPG	225	Crdwll RL	185	4,500
Rhodes & Hicks Drlg Corp	3	btne	370	Crdwll S	185	4,500
Tri-Service Drlg Co	7	gas	370	Natl T-20	370	5,800
Shackelford County						
Irish Drlg Co Inc	4	btne	360	Wichtex R-5	—	4,000
A F Knappenberger & K & H Drlg Co	1	gas	350	Emsco GA-500	500	7,000
Low Drlg Co	1	btne	—	Emsco	290	7,000
	2	btne	—	Wilson	145	3,000
	3	btne	—	Wilson	165	2,000
H F Pettigrew Drlg Co	1	—	—	Mayhew Prtble	—	—
Sojourner Drlg Corp	2	dsl	320	Unit U-15	—	5,000
	5	btne	225	Natl T-8-s	—	3,250
West Central Drlg Co	9	gaso-btne	225	Crdwll H	250	3,000
Sherman County						
Cree Drlg Co Inc	6	gas-btne	255	Wisn Giant	300	5,000
	8	gas-btne	185	Unit U-34	300	4,500
Smith County						
B G Byars Power Drlg Co	1	gas-btne	1170	Beth MC-450	775	11 000
	2	gas-btne	1145	Emsco GA-500	750	10,500
Delta Drlg Co	40	gas-btne	325	Wisn Rdr Gnt	690	8,000
Maxwell Herring Drlg Corp	3	gas	600	Wisn Gnt Rdair	600	9,500
	8	gas	300	Wisn Mogul	250	4,500
Jackson Oil Co	1	dsl	330	Crdwll O	520	6,500
Johnson Drlg Co	1	dsl	300	Wisn Mogul	275	7,500/3½"
	2	dsl	300	Spencer	250	6,000/3½"
Liberty Drlg Corp	4	gas-btne	740	Emsco GB-500	—	9.000
Tex-Mex Drlg Co	12	gas	—	Unit U-15	—	9.000
Trant Drlg Co	3	stm	—	—	—	15,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Starr County						
Clark Fuel Prod Co	2	dsl	740	Wisn Gnt	520	8,500
Del Mar Drlg Co	2	dsl	400	Natl 50	762	8,000
Turnbull & Zoch Drlg Co	7	gas-btne	630	Ideco Rambler	630	10,000/3½"
Stephens County						
E & H Drlg Co	2	gas	275	Unit U-34	225	4,500
Edwards Drlg Co	2	gas-gaso	600	Unit U-15	600	9,000
Ewing Drlg Co	1	btne	—	Emsco C-42	450	5,000
Red River Drlg Co	2	gas	165	Wichtex R-4	140	3,500/3½"
Taylor Expl Co Inc	3	gaso	—	Mayhew	75	1,000
	4	gaso	—	Mayhew	75	1,000
	7	btne	—	Mayhew	—	1,200
Sterling County						
Petroleum Drlg Co	2	dsl	400	Wisn Gnt	600	8,000
Rheay & Reynolds Drlg Co	5	gas	350	Natl 75	1200	10,000
Stonewall County						
Ace Drlg Co	1	gas	680	Emsco G-500	500	7,500
Edgar Davis Drlg Co	11	gas-btne	325	Unit U-15	600	7,500
Drillers Inc	U-15	dsl	—	Unit U-15	600	7,200
T F Hunter Estate	1	gas-btne	700	Wisn Roadair	700	8,500
J & L Drlg Co Ltd	1	dsl	—	Brwstr N-55	500	7,200
Moore & Moore Drlg Co	6	btne	300	Unit U-15	636	9,000
W B Omohundro	8	btne	700	Wisn Rdair	—	8,000
St John Drlg Co	2	gas	300	Natl 50	450	7,000
Wes-Tex Drlg Co	1	btne	338	Unit U-10	326	7,500
Sutton County						
Brannon & Murray Drlg Co	1	gas-LPG	550	Brwstr N-55	550	7,500
Great Western Drlg Co	11	dsl	353	Wisn Gnt Rdmstr	600	9,000
Rheay & Reynolds Drlg Co	3	gas	400	Unit U-15	1200	6,500
Taylor County						
Frank Caraway Drlg Co	1	btne-gas	225	Beth S-50	—	5,000
Dixon Drlg Co	3	gas	500	Natl 50	520	7.500
H O Grace Drlg Co	3	btne	—	—	—	6,000
Hack Drlg Co	2	btne	—	Crdwll S	161	4,500
	3	btne	—	Unit U-15	412	8,500
Herb Expl Co	—	gas-gaso	—	Failing 1500	—	1,750/2⅞"
Irish Drlg Co Inc	2	btne	280	Wichtex R-3	—	3,000

GULF COAST DRILLING SPECIALISTS

J. F. Burdett
President



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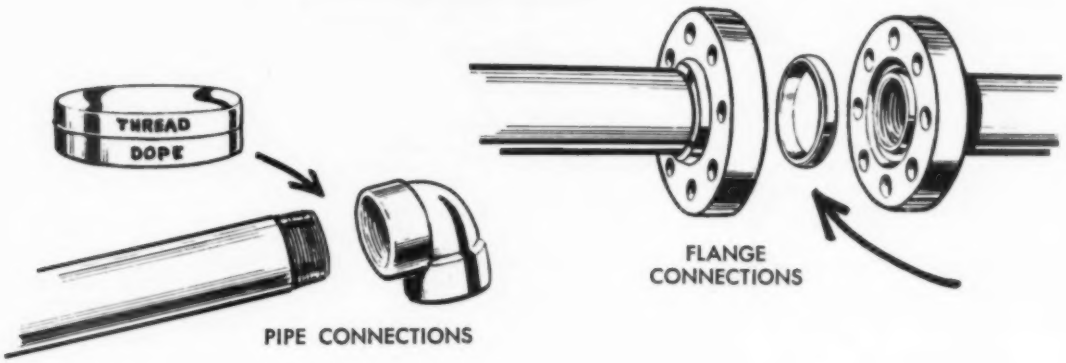
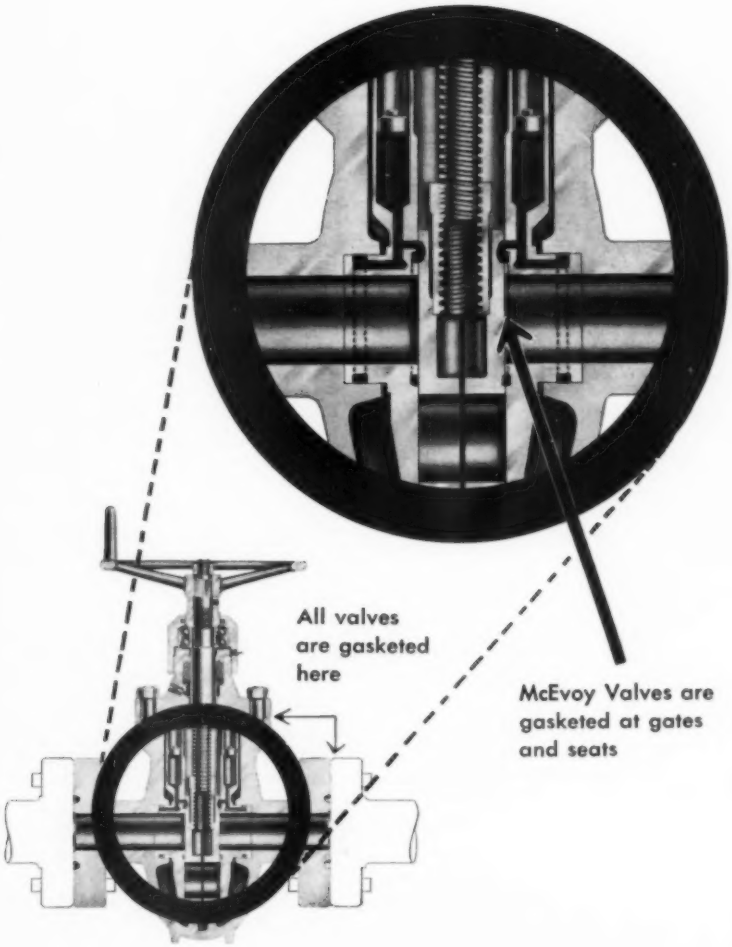


BUT NEGLECT VALVE GATES AND SEATS?



McEvoy Valves are Automatically Gasketed at the Gates & Seats

It is common practice to gasket all screwed or flanged valve connections to insure tightness. But tightness is even more important between valve gates and seats where movement occurs. Leakage not evident from the outside, *does exist* around movable parts in some valves. McEvoy Valves *eliminate* internal leakage.

The exclusive patented McEvoy self-sealing system automatically gaskets between gates and seats after every operation . . . stops leaks the instant they start. Only McEvoy Valves provide this outstanding assurance of tightness and economy.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
J E Miller Drlg Contr	1	btne	165	Natl T-8-S	145	3,400/3½"
	2	btne	200	Natl T-12	165	4,000
Norman Drlg Corp	2	dsl	330	Unit U-10	350	5,000
Rheay & Reynolds Drlg Co	6	gas	300	Natl 50	750	7,000
Robinson Drlg Co	2	gas-btne	155	Crdwll EC	155	6,000/3½"
	6	gas-btne	180	Crdwll OC	450	7,500/4"
	8	btne-gas	180	Unit U-15	450	8,500
Wes-Tex Drlg Co	7	btne	244	Brwstr N-4	280	5,500
Woodson Prod Co	4	dsl	600	Mayhew 5000	270	5,500/4"
Terrell County						
Choya Drlg Co Inc	4	gas-btne	1400	Emsco J-1400	1400	15,000
Helmerich & Payne Inc	48	gas-btne	1200	Natl 110	1300	15,000
Layton & Newell Drlg Co	2	gas-btne	450	Natl 75	780	12,000
Terry County						
Hissom Drlg Co	6	gas	1000	Emsco A-800	1000	11,000
Throckmorton County						
Edwards Drlg Co	3	gas-gaso	600	Unit U-15	600	9,000
H O Grace Drlg Co	1	btne	—	—	—	6,000
Hale Bros Drlg Co	3	gas	—	Unit 34	—	4,500
A F Knappenberger & K & H Drlg Co	2	gas	200	Wlsn Mogul	400	5,000
R-G Drlg Co	3	gas-gaso	—	Wilson	450	6,500
	5	gas-gaso	—	Wilson	650	8,000
Sheets & Walton Drlg Co	3	pwr	365	Brwstr N-4	285	5,000
Tom Green County						
Petroleum Drlg Co	3	gas	400	Natl 50	650	8,000
Tucker Drlg Co	4	dsl	610	Beth J-55	—	9,500
	5	gas	620	Crdwll O	620	9,500
Travis County						
Henderson Drlg Corp	5	gas-btne	800	Natl 55	800	11,000
Trinity County						
Wise Drlg Account	1	gas	450	Unit U-15	450	7,500
Tyler County						
Carnes W Weaver Drlg Co	6	gas-btne	540	Brwstr N-7	—	8,500
Upton County						
Blount Drlg Corp	4	dsl	275	Brwstr N-4	275	5,500
Choya Drlg Co Inc	3	gas-btne	900	Beth MC-650	900	12,000
Coroco Drlg Co	1	gas-gaso	500	Beth 650	650	12,500
Empire Drlg Co	7	gas	650	Wlsn Titan	975	13,500
Helmerich & Payne Inc	37	gas	1200	"Oilwell" 96	1450	15,000
Julkirk Corp	1	gas-btne	600	Natl 50	600	8,000
Carl B King Drlg Co of Tex	10	gas-gaso	1000	Natl 75	1000	12,500
Lowe Drlg Co	3	gas	1000	Natl 100	—	12,500
B L McFarland Inc	8	gas	700	Brwstr N-75	—	12,000
	10	gas	500	Brwstr N-55	—	7,000
Norwood Drlg Co	4	gas-gaso	500	Wlsn Gnt Rdair	600	9,500
Penrod Drlg Co	2	gas-btne	—	—	580	7,000
Fred Pool Drlg Co	1	gas	580	Unit U-15	600	7,500
Sharp Drlg Co	35	gas	1200	Beth M-810	1200	12,000
Triad Drlg Co	5	gas-btne	650	Beth 450	650	12,000
Tri-Service Drlg Co	6	gas	1350	"Oilwell" 96	1350	16,000
Wilbanks & Sutter Drlg Co	1	gas	1050	Unit U-40	1050	10,000
Val Verde County						
Hewgley Drlg Co	2	gas-btne	—	Ideco	1400	14,000
Van Zandt County						
Robert M Bass Drlg Contr	1	gas-LPG	500	Wlsn Rdair	800	10,000
Victoria County						
Appell Petroleum Corp	4	gas-gaso	315	Wlsn Mogul	175	4,000
Harkins & Co	2	dsl	300	Wlsn Giant	300	6,000
	7	dsl	600	Unit U-15	600	8,500
Martin & Holmes OW Serv Co	1	dsl-gas-gaso	770	Crdwll	370	7,000
Viking Drlg Co	1	dsl	475	Natl 50	500	8,500
Waller County						
CBS Workover Co	2	gas-btne	145	Crdwll K	145	2,500
Ward County						
Delta Drlg Co	2	gas-btne	400	Natl 50	450	7,000
Gardner Bros Drlg Co Inc	20	gas-btne	275	Natl T-25	350	4,000
Leatherwood Drlg Co	2	gas	440	Natl T-32	—	7,000
	3	dsl	220	Natl T-20	—	6,000
Lee Drlg Co	7	gas-gaso	440	Beth S-55	—	6,000
Chas E Long Jr Inc	1	gas	200	Unit U-10	400	6,000
M & J Inc	14	gas	150	Crdwll RL	—	3,500
Urice Drlg Co	3	gas-btne	700	Emsco GB-500	700	9,000
Western Serv Drlg Co Inc	13	gas-btne	550	Beth S-45-E	350	5,000
Washington County						
Bass Drlg Co	3	gas-gaso-btne	225	Unit U-34	—	6,500
Wharton County						
W P Taylor Drlg Co	2	gas	—	Natl	900	11,000
Wheeler County						
Falcon Seaboard Drlg Co	33	gas	1050	Beth 1013	1350	16,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Wichita County						
Bolin Oil Co & D H Bolin	10	dsl	300	Wlsn Giant	300	4,500
Hale Bros Drlg Co	1	gas	—	Wlsn Giant	—	8,000
Harvey Drlg Co	3	gas-btne	350	Wlsn Mogul	400	5,000
	5	gas-btne	750	Wlsn Giant	800	8,500
	6	gas-btne	500	Wlsn Giant	500	7,500
Hull Oil Co	1	btne	140	Wlkr-Nr R-2	—	2,000
Lin-Mour Drlg Co	1	gas	315	Wlsn Mogul	400	4,600
Meredith Drlg Co	2	btne	500	Wlsn Giant	225	7,500
W B Omohundro	9	btne	550	Wlsn Rdair	—	6,500
Walters Drlg Co Inc	9	gaso	130	Mayhew 1000	130	800/2⅛"
Wilbarger County						
Bolin Oil Co & D H Bolin	4	gas	350	Wlsn Gnt	500	7,500
Dublin-Kiel	1	LPG	225	Wlsn Mogul	190	2,500
T V Gorman Drlg Contr	1	dsl	200	Wichtex R-3	200	3,000
Gray Drlg Co	1	gas-gaso	220	Wlsn Gnt Rdair	450	5,500
B M Hester	1	btne	325	Natl T-20	200	6,000
Jennings Drlg Co	4	btne-gas	450	Unit U-15	600	8,000
E W Moran Drlg Co	6	gas	225	Wlsn Mogul	160	4,500
Harold Shappell Drlg Co	1	btne	245	Wichtex	145	2,800
Wilson County						
Pegg Bros Drlg Co	3	gas-btne	90	—	90	1,500/2⅛"
Sutton Drlg Co	5	gas-gaso	—	Wlsn	125	1,500
Winkler County						
Arrow Drlg Co	24	dsl	1200	Emsco 1000	—	14,000
Harry Bass Drlg Co	111	gas	1200	Emsco	1200	14,000
Robert M Bass Drlg Contr	2	gas-LPG	350	Brwstr N-45	350	7,000
Bickerstaff & Tibbets Drlg Co	2	gas	325	Brwstr N-4	320	6,000
Blount Drlg Corp	3	gas-btne	275	Unit U-34	175	5,000
Bolin Oil Co & D H Bolin	2	gas	225	Natl T-12	185	4,500
Calco Drlg Co	3	gas-btne	275	Emsco GB-250T	250	5,500
	4	gas-btne	215	Beth Breeze	200	5,500
Camden Drlg Co	1	dsl	300	Natl T-20	300	5,000
Coroco Drlg Co	4	gas-gaso	650	Wlsn Spr Titan	900	15,000
Danforth Drlg Co	1	dsl	240	Ideco H-30	350	5,000
Great Western Drlg Co	16	gas-gaso	775	Unit U-914A	1260	15,000
King-Phillips Inc	3	dsl	622	Ideco H-40D	—	5,500/4"
Layton & Newell Drlg Co	7	stm	500	Natl 34-26-9	1000+	15,000
Lowe Drlg Co	7	gas	750	Wilson	—	10,000
B L McFarland Inc	4	gas	400	Crdwll RL	—	4,500
Triad Drlg Co	1	gas-btne	500	Natl 50	500	7,000
	2	dsl	300	Beth S-45	300	6,000
Western Serv Drlg Co Inc	11	gas-btne	1000	Beth 810	1100	11,000
	12	dsl	250	Natl T-20	520	4,000
Wise County						
Admiral Drlg Co Inc	A	gas-gaso-btne	250	"Oilwell" 64-A	300	7,000
Bolin Oil Co & D H Bolin	6	gas	350	Wlsn Gnt Rdair	250	6,500
Dugger & Herring Drlg Co	1	gas-btne	500	Unit U-15	600	8,500
Hamman Oil & Ref Co	7	dsl	340	Brwstr N-75	600	11,000
John W Harris Drlg Co	1	gas	500	Hou Prtble	450	6,500
	2	gas	500	Emsco GC-500	500	8,000
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	6,000
	2	gas-btne	150	Wlsn Super	150	3,500
J W Hastings Drlg Co	5	gas-btne	864	Wlsn Gnt Rdair	864	8,200
McCutchen & Graham	2	btne	255	Unit U-15	570	7,500
E W Moran Drlg Co	3	dsl	285	Wlsn Giant	650	7,500
Paine Drlg Co	6	btne	500	Wlsn Giant	500	7,000
	7	dsl	450	Wlsn Giant	450	7,000
Thomas & Billups Drlg Co	1	btne	550	Unit U-15	590	8,000
Trio Drlg Co	1	gas	520	Wlsn Giant	—	8,000
	2	dsl-gas	520	Crdwll O	—	8,500
	3	gas	450	Wlsn Giant	—	6,500
	4	gas	450	Natl 50	—	6,500
Walters Drlg Co Inc	12	dsl	—	Mayhew 1000	300	400/2⅛"
Wood County						
Robert M Bass Drlg Contr	5	gas-LPG	300	Wlsn Giant	300	5,500
Big Chief Drlg Co	5	gas	1545	Emsco 1250	1545	15,000
M J Delaney Co	25	stm	—	Emsco UBLS 54	—	15,000
	28	gas-btne	500	"Oilwell" 96	1000	14,000
Gibson Drlg Co	2	gas-btne	226	Wlsn Mogul 42	145	5,000
Yoakum County						
B B M Drlg Co	5	gas-btne	450	Emsco J-750	650	12,000/3½"
Empire Drlg Co	9	dsl	600	Wlsn Giant	600	7,500
	10	gas	400	Brwstr N-4	300	5,500
Frisbie Drlg Co	2	btne	675	Brwstr N-7	675	9,000/4"
Gardner Bros Drlg Co Inc	14	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	4	gas	307	Unit U-15	800	9,000
B L McFarland Inc	6	gas	1000	Brwstr N-95	—	14,000
Tucker Drlg Co	3	gas	600	Ideco TC-600	—	9,500
Western Drlg Co Inc	11	dsl	288	Emsco 350	375	6,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Young County						
Anderson Drlg Co	1	btne	225	Wisn Mogul	—	4,000
Bolin Oil Co & D H Bolin	5	gas	225	Wisn Mogul	190	4,000
Jess P Cross Drlg Contr	1	gas-bthe	250	Wisn Mogul	230	4,500/3½"
Hamilton-Powell Drlg Co Inc	1	gas	225	Wisn Mogul	—	4,500
J W Hastings Drlg Co	4	gas-btne	330	Wisn Torcair	220	5,000
Norwood Drlg Co	8	gas-gaso	300	Wisn	175	4,000
W B Omohundro	10	btne	300	Brwstr N-3	—	4,500/3½"
Oney Drlg Co	5	gas	250	Crdwll S	200	4,000
Wes-Mor Drlg Inc	1	gas-btne	450	Wisn Gnt Rdair	450	6,800
	4	gas-btne	225	Unit U-34	185	4,500/4"
Zapata County						
Longhorn Drlg Co	6	gas-btne	500	"Oilwell" 76	1185	14,000
UTAH						
Carbon County						
Mountain States Drlg Co Inc	11	gas-dsl	1000	Natl 80-B	—	12,500
	15	gas-dsl	1400	Natl 125	—	15,000
Garfield County						
Mountain States Drlg Co Inc	2	gas-dsl	1000	Emsco J-750	—	10,000
Grand County						
Exploration Drlg Co	11	gas	800	Beth S-60	480	8,000
San Juan County						
Anschutz Oil Co Inc	2	dsl	900	Wisn Giant	560	8,500
Arapahoe Drlg Co	2	gas-btne	300	Natl T-32	320	6,000
	4	gas-btne	375	Natl 50-A	680	8,000
Basin Drlg Corp	1	gas	600	Unit U-15	600	8,000
	2	gas	600	Unit U-15	600	8,000
Calvert Drlg Inc	20	dsl	350	Ideco H-525	600	8,500
Carmack Drlg Co	4	dsl	472	Natl T-32	320	6,000
D-K Drlg Co	3	gas	500	Natl 50	500	6,500
Exeter Drlg Co	3	btne	630	Natl 50-A	630	8,500
Exploration Drlg Co	1	gas	470	Beth S-60	500	8,000
	8	gas	670	Unit U-15	600	8,000
	15	gas	800	Natl 75-CA	900	11,000
	16	gas	625	Natl 75	600	9,000
Gardner Bros Drlg Co Inc	17	gas-btne	550	Natl 50-A	700	8,500
Great Western Drlg Co	14	dsl	320	Unit U-15	800	9,000
	30	gas-gaso	500	Unit U-15	750	7,500
	42	dsl	500	Emsco G-500	800	9,000
Hewit-Gulick Drlg Co	3	gas-btne	600	Natl 50-CA	900	8,000
R L Manning Co	4	gas-btne	600	Emsco 450	450	7,000
	12	gas-btne	500	Emsco GA-350	450	7,000
	16	gas-btne	475	Natl T-32	450	6,000
Moran Bros Inc	7	gas	700	Wisn Giant	750	10,000
	8	gas	700	Wisn Giant	750	10,000
	9	gas	700	"Oilwell" 66	750	10,000
	16	gas	650	Unit U-15	700	7,500
Mountain States Drlg Co Inc	6	dsl	600	Natl 50	—	7,500
George Noland Drlg Co Inc	9	gas-btne	—	Emsco G-500	730	8,500
The Novak Drlg Co	2	gas	300	Unit U-10	—	6,500
Rhodes Drlg Co	5	gas	450	Unit U-15	675	9,000
	11	gas	240	Emsco 350	360	5,000
R W Rine Drlg Co	2	dsl	520	Brwstr N-7	600	8,500
	6	dsl	520	Brwstr N-75	750	12,000
Paul F Rutledge	4	gas	525	Beth C-50	525	7,000
Uintah County						
Dellson Drlg Co	3	gas-btne	520	Emsco GB-500	520	7,500
Kerr-McGee Oil Ind Inc	4	gas	900	Natl 75	832	11,500
	23	gas	650	Natl 50	556	9,000
	42	gas	970	Natl 75	818	11,500
Miracle & Wooster Drlg Co	—	gas	850	Unit U-15	500	7,500
Mountain States Drlg Co Inc	3	gas-dsl	600	Natl 50-A	—	7,500
	4	gas-dsl	600	Emsco GB-500	—	9,000
WASHINGTON						
Benton County						
Miracle & Wooster Drlg Co	—	gas	850	"Oilwell" 76	700	10,000
Grays Harbor County						
Colorado Wyoming Drlg Co	2	dsl	668	Natl 55	668	12,000
WEST VIRGINIA						
Greenbrier County						
Gordon Drlg Co	10	gas-LPG	600	"Oilwell" 66	500	9,500
Nicholas County						
Delta Drlg Co	29	dsl	750	Emsco J-750	750	12,000
Randolph County						
Delta Drlg Co	27	dsl	380	Emsco GA-350	350	6,000
Roane County						
Eakle & Holder Drlg Co	5	dsl	600	Natl 50	600	8,500
WYOMING						
Albany County						
Dellson Drlg Co	2	gas-btne	430	Emsco GA-250	335	6,000
Big Horn County						
A O Bullock Drlg Co	1	gas	220	Wichtex R5	—	3,500
Delta Drlg Co	28	dsl	350	Frnks SAL-6000	600	5,000
Campbell County						
Anschutz Oil Co Inc	10	dsl	800	Brwstr N-55	600	8,000
Falcon Seaboard Drlg Co	9	gas-btne	325	Unit U-15	450	8,500
Will I Lewis Drlg Co	6	dsl	1450	Unit U-20	1450	14,000
Reserve Drlg Co Inc (Casper)	3	gas-LPG	500	Natl 50	500	7,500
A L Schlaikjer	1	gas	700	Wisn Gnt Rdair	—	8,000
Converse County						
Dyer Drlg Co	2	gas-gaso	325	"Oilwell" 64-B	480	7,000
R L Manning Co	7	gas-btne	750	Emsco G-500	750	8,000
	15	dsl	540	Emsco GB-250	340	6,000
Crook County						
True Drlg Co	4	gas-gaso	400	Emsco GA-250	250	6,000
	5	elec	400	Emsco H-46	400	9,000
	6	gas-gaso	500	Beth Twstr	600	8,500
	8	gas-gaso	500	Natl 50	500	7,500
Fremont County						
Carpenter-Trant Drlg Co	6	dsl	450	Wisn Giant	640	7,500
Kerr-McGee Oil Ind Inc	28	gas	770	Natl 75	832	11,500
R L Manning Co	2	gas-btne	600	Emsco 300	300	5,500
	11	gas-btne	1080	Emsco J-1000	1305	13,000
George Noland Drlg Co Inc	10	gas-btne	—	Emsco PDM-36	440	5,500
	11	gas-btne	—	Unit U-15	730	8,500
Roden & McRae Drlg Corp	5	gas	255	Emsco GA-250-T	270	4,500
Hot Springs County						
Arrow Drlg Co	14	gas	600	Wisn	—	8,000
Dellson Drlg Co	1	gas-btne	740	Emsco GB-500	740	8,500
Dyer Drlg Co	3	dsl	185	Failing 66	300	3,500
Johnson County						
Roden & McRae Drlg Corp	1	dsl	255	Emsco GA-350	570	5,000
Lincoln County						
Kerr-McGee Oil Ind Inc	31	gas	1000	Natl 100	1680	15,000
R L Manning Co	5	gas-btne	750	Emsco G-500	750	8,000
Natrona County						
Big Horn Drlg Co Inc	1	dsl	220	Brwstr N-4	375	4,500
	3	dsl	600	Emsco GB-250	360	6,500
Bueno Drlg Co	1	dsl	700	Natl T-20	270	5,000
A O Bullock Drlg Co	2	gas	225	Crdwll S	—	4,000
Carpenter-Trant Drlg Co	9	dsl	250	Franks	300	5,000
Roden & McRae Drlg Corp	6	dsl	122	Frnks Rocket TD-44	180	2,000
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500
Taylor Expl Co Inc	5	gaso	—	Mayhew	75	1,000
	8	btne	—	Failing	—	2,000
True Drlg Co	7	dsl	185	Failing	165	3,500
Niobrara County						
George Noland Drlg Co Inc	6	gas-btne	—	Wisn Mogul	440	4,000
Olds & Wrather Drlg Co	1	gas	235	Wisn Mogul	350	6,000
Park County						
Mountain States Drlg Co Inc	9	gas-dsl	1400	Natl 125	—	15,000
Roden & McRae Drlg Corp	2	dsl	185	Emsco GA-300	270	4,500
Platte County						
Morrison Drlg Co Inc (Wyo)	8	dsl	210	Frnks Comet	225	5,000
Sublette County						
Delta Drlg Co	18	dsl	600	Natl 75	650	9,500
Fitzpatrick Drlg Co Inc	1	gas-btne	550	Unit U-15	550	8,250/4"
Sweetwater County						
Brack Drlg Co Inc (Colo)	6	dsl	—	—	606	8,500
Carpenter-Trant Drlg Co	8	btne	800	Wisn Titan	1320	12,000
Delta Drlg Co	23	dsl	520	Emsco GA-500	500	8,000
Falcon Seaboard Drlg Co	25	dsl	212	Beth S-55	212	6,500
Fitzpatrick Drlg Co Inc	4	gas-btne	900	Wisn Titan Rdr	900	12,500
Nye & Snell Drlg Co	3	dsl	500	Wisn Atlas	800	11,000
	4	dsl	320	Unit U-15	320	6,000
Washakie County						
Clark Drlg Co	—	dsl	—	Natl 50	525	6,500
Don Johnston Drlg Co	5	gas-btne	775	Natl 75	775	10,000
R L Manning Co	6	gas-btne	900	Emsco GB-800	1125	11,000
	10	gas-btne	1275	Emsco J-750	1125	11,000
	17	gas-btne	1045	Emsco GC-500	770	10,000
Mountain States Drlg Co Inc	14	dsl	800	Ideco M-1000	—	10,000
George Noland Drlg Co Inc	7	gas-btne	—	Emsco PDM-36	440	5,000
Weston County						
Anschutz Oil Co Inc	15	dsl	1000	"Oilwell" 76	1000	12,000
Dyer Drlg Co	1	gas-gaso	325	Natl T-32	365	6,000
Olds & Wrather Drlg Co	2	gas	675	Emsco GB	675	7,000
	3	dsl	900	Natl 50	900	7,500
	4	dsl	240	Crdwll RL	180	4,000
True Drlg Co	10	gas-LPG	675	Unit U-15	675	8,500

U. S. Contract CABLE TOOL Drilling Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top of Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALABAMA						
Marion County						
Harry L Cullet	1	gas-gaso-btne	125	3000	3500	Crdwll H
	3	gas-gaso-btne	250	7000	7500	Special
Talladega County						
Harry L Cullet	2	gas-gaso-btne	150	5000	5500	Star Spdr
ARIZONA						
Mohave County						
Aldridge & Stroud Inc	10	—	145	4000	4000	B Erie 60-L
	11	LPG	145	6000	6000	Wichita 61
ARKANSAS						
Ouachita County						
H F Hatcher & Son	1	gas-gaso-btne	140	4000	5500	Crdwll KL-225
CALIFORNIA						
Ventura County						
United Drlg Co	2	gas	75	2000	—	Keystone A-50
COLORADO						
Cheyenne County						
Signal Oilfield Serv	11	dsl	—	—	8000	Crdwll RL
Morgan County						
Signal Oilfield Serv	2	gas-btne	215	—	8000	Frnks Rocket
Routt County						
Western Drlg Co Inc	5	btne	185	—	—	B Erie 48-L
	7	dsl	185	—	—	B Erie 48-L
Weld County						
Signal Oilfield Serv	4	dsl	200	—	8000	Crdwll RL
ILLINOIS						
Christian County						
LaMac Oil Co	1	dsl	600	4700	—	Wisn Giant
	2	gas	75	2000	2500	B Erie 24-L
C W Strotman Drlg Co	1	gas	145	3600	4500	Crdwll H
	2	gas	145	3600	4500	Crdwll H
V S & S Drlg Co	1	gas	—	—	2000	Wichtex
Clay County						
Shulman Bros	2	gas-gaso	—	4000	—	Crdwll H
C W Strotman Drlg Co	3	gas	130	3000	3500	Crdwll K
Coles County						
Cummins Drlg Co	C-6	gas-gaso	78	2500	3500	B Erie 28-L
Crawford County						
W L Dillier	1	gas	65	1500	2000	B Erie 60-L
Fayette County						
Cummins Drlg Co	C-1	gas-gaso	65	1500	2000	B Erie 24-L
	C-2	gas-gaso	65	1500	2000	B Erie 24-L
	C-3	gas-gaso	65	1500	2000	B Erie 60-L
	C-4	gas-gaso	65	1500	2000	B Erie 60-L
	C-5	gas-gaso	78	2500	3500	B Erie 28-L
Franklin County						
C E Brehn	4	btne	184	—	5000	Crdwll K
Gallatin County						
V S & S Drlg Co	3	gas	—	3500	3500	Cooper
Hamilton County						
C W Strotman Drlg Co	4	gas	175	3500	4000	B Erie 36-L
Jasper County						
J W Rudy	3	btne	130	—	4000	Crdwll K
Lawrence County						
W L Dillier	2	gas	65	1500	2000	B Erie 60-L
Payne Bros Drlg Co	2	dsl	150	3000	4000	B Erie 36-L
Marion County						
C E Brehn	8	btne	184	—	5000	Crdwll K
Perrine & Perrine Drlg Contr	2	btne	145	—	6000	B Erie 36-L
Graham Powell	1	btne	500	4200	4200	B Erie 36-L
Richland County						
Don Slape Drlg Co	1	btne	—	—	—	Crdwll K
Wabash County						
Payne Bros Drlg Co	1	dsl	150	3000	4000	B Erie 36-L
INDIANA						
Dubois County						
Highland Oil Co	1	dsl	—	2000	—	B Erie 24-L
Gibson County						
Highland Oil Co	2	dsl	—	3000	—	B Erie 28-L
Jennings County						
Payne Bros Drlg Co	3	dsl	150	3000	4000	B Erie 36-L
Posey County						
Princeton Mining Co	1	gas	175	—	3500	Crdwll MO
South State Drlg	2	dsl	110	—	10,000	Crdwll R
IOWA						
Dallas County						
Kirby Oil Ind	—	gas-gaso	145	—	—	B Erie 28-L

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
KANSAS						
Barber County						
Mobile Drlg Co	2	gas	100	—	5000	Crdwll
Patton Drlg Co Inc	3	gas	—	—	—	Crdwll
Barton County						
Signal Oilfield Serv	1	dsl	200	—	6000	Crdwll RL
Butler County						
Rex & Morris Drlg Co	1	dsl	—	3500	4500	B Erie 36-L
Cowley County						
Carter Drlg Co	1	LPG	145	3500	6500	Wlkr-Nr S-43
	3	LPG	160	2000	4500	Wisn Mogul
SeRoBee Drlg Co Inc	1	btne	—	4000	—	Crdwll RL
Elk County						
R L Horn & Sons Drlg Co	1	dsl	60	1600	2000	Star 72
Ellis County						
K Smith Cable Tools	1	gas-prop	145	—	—	Wlkr-Nr
Gove County						
Signal Oilfield Serv	3	gas	145	—	6000	Crdwll RL
Graham County						
Signal Oilfield Serv	9	dsl	150	—	6000	Crdwll RL
Kiowa County						
Graham Michaelis Drlg Co	4	dsl	175	—	8000	Crdwll RL
Marion County						
Strait Drlg Inc	1	gas	175	3500	4000	B Erie 36-L
McPherson County						
SeRoBee Drlg Co Inc	2	btne	—	4000	—	Crdwll RL
Shields Oil Producers	2	dsl	160	3500	7000	B Erie 48-L
Meade County						
Dunnam & Wyant Drlg Co	1	LPG	145	—	8000	Crdwll RL
Graham-Michaelis Drlg Co	1	dsl	175	3000	8000	Crdwll
	2	dsl	175	3000	8000	Crdwll
Montgomery County						
Veeder Supply & Dev Co	BE 2	dsl	120	3500	4500	B Erie
Morton County						
Graham-Michaelis Drlg Co	3	dsl	150	3500	6000	B Erie 36
Rooks County						
Mobile Drlg Co	5	gas	100	—	5500	Crdwll
Russell County						
Shields Oil Producers	3	dsl	160	3500	7000	Crdwll RL
Sedgwick County						
Carter Drlg Co	2	LPG	145	2000	4500	Wlkr-Nr C33
Mobile Drlg Co	1	gas	75	—	3600	Crdwll
	3	gas	100	—	5500	Crdwll
Paul Septer Drlg Co	7	btne	—	4500	—	B Erie 36-L
Stafford County						
Mobile Drlg Co	4	gas	100	—	5500	Crdwll
Signal Oilfield Serv	7	gas	145	—	5000	Wlkr-Nr C-34
KENTUCKY						
Hopkins County						
Riley and Gammon	1	dsl	60	1200	1800	B Erie 22
Muhlenberg County						
Jack and H P Read	2	prop	78	3500	—	B Erie 28-L
	3	gaso	65	2000	—	B Erie 60-L
Ohio County						
South State Drlg	3	dsl	110	—	4200	Cooper
Union County						
Riley and Gammon	2	gaso	30	600	1000	B Erie 20
Webster County						
Shulman Bros	1	gas-gaso	—	4000	—	Crdwll H
LOUISIANA						
Red River Parish						
Jack L Story	S-1	dsl	100	8000	9000	Wlkr-Nr C-37
MICHIGAN						
Bay County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
	—	dsl	150	5000	5000	Natl
Gladwin County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Union Rotary Corp	5	gas-gaso-LPG	150	7500	10,000	Crdwll RL
Gratiot County						
McClure Oil Co	3	gas	145	5000	5000	B Erie 36-L
Hillsdale County						
McClure Oil Co	5	gas	145	4500	4500	B Erie 36-L
Union Rotary Corp	6	gas-gaso-LPG	180	7500	10,000	Crdwll RL
Isabella County						
Union Rotary Corp	2	gas-gaso-LPG	120	5000	7000	Crdwll KL
Missaukee County						
Union Rotary Corp	1	gas-gaso-LPG	120	5000	7000	Crdwll KL

THOROUGH

measure mud service by

MILWHITE

mud sales company

Houston, Texas

A DIVISION OF MISSISSIPPI RIVER FUEL CORPORATION

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Montcalm County						
McClure Oil Co	1	gas	145	5000	5000	B Erie 36-L
	2	gas	145	5000	5000	B Erie 36-L
	4	gas	145	4500	4500	B Erie 36-L
Oscoda County						
Union Rotary Corp	3	gas-gaso-LPG	150	7500	10,000	Crdwll RL
Osceola County						
Gordon Drlg Co	5	gas-LPG	150	4000	5000	Crdwll R
Saginaw County						
Muskegon Development Co	—	LPG	165	6000	6000	Wlkr-Nr S-33
Tuscola County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Union Rotary Corp	4	gas-gaso-LPG	150	7500	10,000	Crdwll RL
Wayne County						
Bernhardt Drlg Co	1	btne	175	4000	—	B Erie 36
MONTANA						
Fallon County						
Signal Oilfield Service	10	dsl	225	—	12,000	Frnks Clpr
Glacier County						
M-H-O Drilling Co	4	gas-btne	165	3500	5000	B Erie 36-L
	7	dsl	220	6000	8000	B Erie 48-L
Pondera County						
J W Lawrence	1	gas-gaso	125	3500	—	Natl
Treasure State Drlg Co	1	dsl	140	3500	4500	B Erie 36-L
	1	gas	140	3500	4500	B Erie 36-L
Teton County						
J W Lawrence	2	gas-gaso	175	5000	—	B Erie
Toole County						
Oien Oil Corp	1	dsl	150	3000	5000	B Erie 36-L
	2	gas-LPG	150	3000	5000	B Erie 36-L
NEBRASKA						
Banner County						
Eatmon Drlg Co	3	prop	—	—	6000	Wlkr-Nr
Hitchcock County						
Signal Oilfield Service	5	dsl	200	—	8000	Crdwll RL
Kimball County						
Eatmon Drlg Co	1	prop	—	—	8000	Crdwll RL
	2	prop	—	—	8000	Crdwll RL
Richardson County						
Nemaha Oil Co	1(wo)	gas	150	—	4500	Wichtex C-60
NEW MEXICO						
Eddy County						
Aldridge & Stroud Inc	1	LPG	140	4000	5000	B Erie 36-L
	8	LPG	145	4500	4500	Wichita 61
Donnell Drlg Co	1	gas-btne	—	5000	5000	Wichita 61
Kersey & Company	1	gas-gaso	185	5000	5000	Natl 3
	2	gas-gaso	120	3000	3500	Wich Spddr 55
	3	gas-gaso	120	4000	4500	Wich Spddr 61
	4	gas-gaso	120	4000	4500	Natl 3
Needham Drlg Co	1	dsl	160	5000	—	Wich Spddr 66
	2	LPG	180	5000	—	Wich Spddr 66
Jack Plemons Drlg Co	1	LPG	150	5000	—	Natl
	2	LPG	144	—	4500	B Erie 36-L
S P Yates Drlg Co	3	LPG	150	3500	—	Wichita 55
	4	LPG	130	3000	—	Ft Wrth Spr J
	5	LPG	180	6000	—	Ft Wrth Jumbo J
	6	LPG	180	6000	—	Ft Wrth Jumbo J
Lea County						
Western Drlg Co Inc	10	btne	185	—	—	B Erie 48-L
McKinley County						
Signal Oilfield Service	12	dsl	—	—	8000	Crdwll RL
San Juan County						
Signal Oilfield Service	13	dsl	—	—	8000	Crdwll RL
OHIO						
Hocking County						
R A Cooper Drlg Co	1	gas	—	4000	4000	Natl 12
Wyandot County						
H J Lininger	1	gas-gaso	78	2500	—	Beth Cyclone
	2	dsl	175	3500	—	L C Moore
	3	gas-gaso	65	1800	—	Beth Cyclone
OKLAHOMA						
Beaver County						
Chambless-Rosen Drlg Co	4	gas-btne	145	—	10,000	Crdwll RL
Beckham County						
Bolin Oil Co & D H Bolin	8	gas	145	4500	—	Wlkr-Nr S-45
Caddo County						
G H Ray Well Service Co	1	gaso-gas	—	12,000	—	Wlsn Master
	5	gas-gaso	—	12,000	—	Crdwll RL
	6	gaso-gas	—	12,000	—	Crdwll S-60
	7	gaso-gas	—	4500	—	Wilson
	8	gaso-gas	—	12,000	—	Crdwll
Creek County						
Acacia Drlg Co	1	btne	175	4500	4500	B Erie 36-L
	2	btne	175	4500	4500	B Erie 36-L
Duke Anderson Drlg Co	2	btne-gas	145	—	9000	Crdwll R
Bennett Drlg Co	2	LPG	—	3500	4000	Star 45
4-J Drlg and Well Serv Co	1	gaso	—	—	4500	B Erie 36-L
	2	gaso	—	—	3500	Wlkr-Nr
C H Hartman	1	—	—	3500	—	—
M L (Mike) Marrs Drlg Co	1	LPG	145	3500	4500	B Erie 36-L
	2	LPG	145	3500	5000	B Erie 36-L
	3	LPG	145	3500	5000	B Erie 36-L
	4	LPG	145	3500	5000	B Erie 36-L
Garfield County						
Hayward Drlg Co	2	gas	145	4000	—	Brwstr
Grant County						
Sooner Drlg Co	4	LPG	145	5000	7500	Wlkr-Nr
Kay County						
Mora Drlg Co	4	gas	300	7000	—	Wlsn Giant
Dave Morgan Drlg Co	—	LPG-gas	145	—	6500	Crdwll RL
Kiowa County						
Dublin-Kiel	2	LPG	140	2000	3000	Wlkr-Nr S-32
Ellis Drlg Corp	2	btne	45	2400	3000	B Erie 28-L
Lincoln County						
Foster Drlg Co	1	prop	135	—	3500	Cooper
	3	prop	135	—	4000	Wlkr-Nr
Logan County						
Chambless-Rosen Drlg Co	3	gas-btne	145	—	10,000	Crdwll RL
Muskogee County						
Ralph G Ladd	1	gas-gaso	65	1750	2500	Star Spddr K
Noble County						
Chambless-Rosen Drlg Co	2	gas-btne	145	—	10,000	Crdwll RL
Nowata County						
Bennett Drlg Co	6	LPG	—	1750	2250	B Erie 24-L
	10	LPG	—	2000	2500	B Erie 60-L
Okfuskee County						
Bodard Drlg Co	2	gas	225	7000	7000	Wlkr-Nr C-34
Floyd R Hyer	1	gas-gaso-btne	60	2250	2750	Star Spddr K
	—	—	—	2200	—	Star Spddr K
Skinner & McDougal Drlg Co	1	gaso-btne	145	4000	6500	Crdwll
	2	gaso-btne	145	4000	5500	Wlkr-Nr
Okmulgee County						
Acacia Drlg Co	3	btne	175	4500	4500	B Erie 36-L
Bennett Drlg Co	8	LPG	—	2750	3250	B Erie 28-L
D & J Drlg Co	—	btne	140	5000	5000	45 Star Spddr
Gold-Mar Drlg Co	1	LPG	125	2500	3500	Wich Spddr 25
Osage County						
W C Holt Drlg Co	1	gas	130	3000	4000	Wlkr-Nr
	1	gas	140	3500	4000	Wlkr-Nr
Signal Oilfield Serv	8	gas	145	—	5000	Wlkr-Nr C-34
Payne County						
Duke Anderson Drlg Co	A	btne-gas	140	—	4500	B Erie 36-L
	1	btne-gas	145	—	9000	Crdwll R
	3	btne-gas	145	—	9000	Crdwll R
Mora Drlg Co	1	dsl	250	5000	—	Wlsn Mogul
Skinner & McDougal Drlg Co	3	gas-btne	145	4000	5500	Crdwll
Pontotoc County						
J G Cantrell Drlg Co	1	gaso	25	—	1800	Allis Chmrs Spddr
Joe Lawrence Drlg Co	1	gas	160	3500	3800	Crdwll H
Pottawatomie County						
Duke Anderson Drlg Co	—	gas-btne	145	—	6000	Wlkr-Nr
Mora Drlg Co	6	dsl	250	5000	—	Wlsn Mogul
Sooner Drlg Co	2	LPG	145	5000	7500	Wlkr-Nr
	6	gas-LPG	145	—	6500	Crdwll RL
Rogers County						
Bennett Drlg Co	9	LPG	—	3500	4500	Wlkr-Nr 34
Seminole County						
Troup & Suttles Inc	1	gas-gaso	145	—	9000	Wlkr-Nr 33
Stephens County						
Thompson Drlg Co	1	LPG	150	1500	2000	Extell
Tulsa County						
Bar-Lee Drlg Co	1	LPG	120	3000	3500	Wlkr-Nr 32
J M Corbett	1	gas	—	5000	6500	Ft Wrth
J M C Drlg Interests	2	gas	—	1500	—	Keystone
Mora Drlg Co	7	gas	200	3500	—	Natl T-12
Washington County						
Bennett Drlg Co	3	LPG	—	2750	3250	B Erie 28-L
	5	LPG	—	2750	3250	B Erie 28-L
PENNSYLVANIA						
Allegheny County						
Cecil Chisler & Son	2	gas-gaso	145	5000	5000	B Erie Spddr 36-L
Berks County						
C S Garber & Sons Inc	33	gas-gaso	32	1500	—	—
	34	gas-gaso	32	1500	—	—

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Bucks County						
C S Garber & Sons Inc	29	gas-gaso	32	1500	—	—
	32	gas-gaso	32	1500	—	—
Clearfield County						
Fairman Drlg Co	2	dsl	225	7500	8000	B Erie Spddr 48-L
	3	gas	225	7500	8000	B Erie Spddr 48-L
	4	gas	225	7500	8000	B Erie Spddr 48-L
	5	dsl	170	5000	6000	B Erie Spddr 36-L
Indiana County						
Fairman Drlg Co	1	dsl	225	7500	8000	B Erie Spddr 48-L
Lebanon County						
C S Garber & Sons Inc	30	gas-gaso	32	1500	—	—
	31	gas-gaso	32	1500	—	—
TEXAS						
Cochran County						
Art West Drlg Co	2	gas	145	—	8000	Crdwll RL
Comanche County						
Kent & Preston	2	btne	120	4000	4000	Ft Wrth Jumbo
Cooke County						
Russell & Russell Drlg & Prod Co	1	gaso	80	2500	2500	Ft Wrth Spr H
Crane County						
Aldridge & Stroud Inc	9	LPG	—	6000	6000	Ft Wrth J
Carey & Parker Inc	2	gas-gaso-btne	—	—	10,000	Crdwll RL
Crockett County						
Buck Jones Drlg Co	1	btne	140	4000	4000	Wlkr-Nr 33
Ector County						
Carey & Parker Inc	4	gas-gaso-btne	—	—	10,000	Crdwll RL
	5	gas-gaso-btne	—	—	9000	Crdwll RL
McQueen & Stout Drlg Co	16	LPG	185	5000	5000	Crdwll RL
	18	LPG	145	5000	—	Natl 3
	20	LPG	185	5000	5000	Crdwll RL
Art West Drlg Co	1	gas	185	—	8000	Crdwll RL
	6	gas	185	—	9000	Wlsn Giant
Garza County						
Ellis Drlg Corp	1	btne	45	2400	3000	B Erie 28-L
Western Drlg Co Inc	2	btne	145	—	—	B Erie 36-L
Gray County						
C P Drlg Co	3	gas-btne	125	3500	4000	B Erie 36-L
	6	gas-btne	125	3500	4000	Wlsn Mogul
Holt Bros Drlg Co	1	gas-btne	—	4000	—	B Erie 36-L
I J Huval Well Serv Co	1	gas-gaso-LPG	145	4000	10,000	Wlsn Mogul Spdr
	2	gas-gaso-LPG	145	4000	10,000	Wlsn Mogul Spdr
	—	gas-gaso-LPG	145	5000	10,000	Wlsn Mogul Spdr
Murphy & McKernan	1	gas-gaso	145	4500	5500	B Erie 36-L
	2	gas-gaso	145	4500	5500	B Erie 36-L
Howard County						
Carey & Parker Inc	1	gas-gaso-btne	—	—	4000	Clark 71
C D Turner Drlg Co	1	btne	145	3500	8000	Wlkr-Nr C-37
Hutchinson County						
C F Hills Drlg Co	2	gas-btne	145	5000	9000	Wlkr-Nr S-33
	3	gas-btne	145	6000	7800	Wlkr-Nr C-34
J R McGill	1	gas-gaso	—	—	—	B Erie
	2	gas-gaso	—	—	—	B Erie
Robinson Brothers Drlg Co	1	gas	200	4500	5000	B Erie 48-L
Irion County						
James Smith Drlg Contr	1	gaso-LPG	145	3500	4500	B Erie 36-L Spdr
Jim Wells County						
H R Smith	5	gas	350	6500	—	Ideco Rambler
Live Oak County						
H R Smith	4	gas	750	14,000	—	Brwstr N-75
Lubbock County						
Western Drlg Co Inc	3	btne	145	—	—	B Erie 36-L
	4	btne	185	—	—	B Erie 48-L
	8	btne	185	—	—	B Erie 48-L
Maverick County						
Errol Elkins Drlg Co	2	LPG	150	5000	6500	B Erie 36
W H McGarr Ind	1	gas-LPG	120	4500	4500	Wich 61
	2	gas-LPG	100	2500	2500	Ft Wrth Spr D
Oney Drlg Co	1	gas	165	5500	—	Wichita
Louis Pitcock Drlg Co	1	dsl	225	6000	7000	Wich 66
McCulloch County						
Kent & Preston	1	dsl	160	6000	—	Ft Wrth J-37
Mitchell County						
Ellis Drlg Corp	3	btne	60	4000	5000	B Erie 36-L
Willard Gladson & Odstrcil Bros Drlg Co	3	btne	—	—	—	B Erie 36-L
Palo Pinto County						
E & H Drlg Co	1	gas-btne	550	7500	10,000	Unit U-15
Panola County						
Dudley C Beene Inc	3	gas	145	5000	10,000	Wlsn Mogul

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top of Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Pecos County						
Aldridge & Stroud Inc	2	LPG	525	2500	5000	B Erie 36-L
	4	LPG	—	2500	2500	Ft Wrth D
Reagan County						
Wilbanks & Rutter Drlg Co	2	gas	—	—	—	—
Runnels County						
Jones Well Serv Co	2	gas-gaso	175	3500	6000	B Erie 36-L
Shackelford County						
J Conley Miles Drlg Co	1	btne	114	2500	3500	Ft Wrth D
Three Sisters Drlg & Prod Co	1	LPG	145	3500	4500	Ft Wrth Spr
Sherman County						
C P Drlg Co	8	gas-btne	125	3500	4000	B Erie 36-L
Stephens County						
E & H Drlg Co	2	gas-btne	225	4500	6000	Unit U-34
Taylor County						
Jones Well Serv Co	1	gas-gaso	175	3500	6000	B Erie 36-L
	3	gas-gaso	175	3500	6000	B Erie 36-L
West Central Drlg Co	2	gas-gaso	—	—	—	Ft Wrth J
Upton County						
Aldridge & Stroud Inc	11	—	145	4000	4000	Wichita 55
Brown & Thorp Drlg Co	2	LPG	135	5500	—	Wichita 66
	3	LPG	180	4000	—	Ft Wrth F-37
	4	LPG	135	4000	—	Ft Wrth F
	5	LPG	135	4000	—	Ft Wrth D
	6	LPG	180	4000	—	Ft Wrth F
	7	LPG	135	4500	—	Wichita 61
	8	LPG	135	3500	—	Ft Wrth D
	9	LPG	135	3500	—	Ft Wrth D
	10	LPG	135	3500	—	Wichita 55
	11	LPG	135	3500	—	Ft Wrth D
Buck Jones Drlg Co	2	btne	100	2500	2500	Wlkr-Nr 32
	3	btne	150	5000	5000	Natl 3
Art West Drlg Co	7	dsl	125	—	8000	Crdwll RL
Ward County						
Aldridge & Stroud Inc	7	LPG	145	—	8500	Crdwll RL
Hissom Drlg Co	5	gas	180	7500	10,000	Crdwll RL
Art West Drlg Co	3	gas	145	—	8000	Crdwll RL
	4	gas	145	—	8000	Crdwll RL
Wichita County						
Joe Hale Co	4	gas	145	—	6500	Wlkr-Nr C-37
	5	gas	145	—	6500	Wlkr-Nr C-37
Lin-Mour Drlg Co	2	gas	125	—	6500	Wlkr-Nr C-34
Ramey Well Service	1	LPG	140	—	8000	Wichtex E-75
Wilbarger County						
Ramey Well Service	2	LPG	140	—	8000	Wichtex E-75
Williamson County						
H J Steward	1	gaso	60	—	2000	Ft Wrth D
Winkler County						
Donnell Drlg Co	2	gas-btne	—	5000	5000	Wichita 61
	3	gas-btne	—	5000	5000	Wichita 55
Art West Drlg Co	5	gas	145	—	6000	Crdwll KL
Young County						
Heathman Oil	1	dsl	—	4500	4500	Crdwll Spdr RI
Oney Drlg Co	2	gas	145	5500	—	Wichita
	3	gas	210	6500	—	Wichita
	4	gas	145	5500	—	Ft Wrth
UTAH						
Grand County						
Walker Bros Drlg	2	dsl	—	—	—	Mayhew 1000
San Juan County						
Signal Oilfield Service	6	gas-btne	200	—	10,000	Franks
Uintah County						
Charles M Jameson	1	gas-gaso	—	—	—	B Erie 36-L
WEST VIRGINIA						
Fayette County						
Allen Drlg Co	7	gas	175	3500	5000	Natl Mach 2
Logan County						
Allen Drlg Co	1	gas	128	5000	6000	B Erie Spdr 36-L
Mingo County						
Allen Drlg Co	2	gas	145	5000	6000	B Erie Spdr 36-L
	3	gas	128	5000	6000	B Erie Spdr 36-L
Wetzel County						
Cecil Chisler & Son	1	gas-gaso	78	3500	3500	B Erie Spdr 28-L
WYOMING						
Converse County						
Morrison Drlg Co Inc (Wyo)	3	btne	185	5500	8000	Crdwll
Fremont County						
Morrison Drlg Co Inc (Wyo)	2	btne	185	5500	8000	Crdwll
Natrona County						
Morrison Drlg Co Inc (Wyo)	1	btne	145	4500	6000	Crdwll
	4	btne	185	5500	8000	Crdwll
Prairie Drlg Co Inc	1	—	—	—	10,000	—

CANADIAN DRILLING CONTRACTORS

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

Arrow Drlg Co 201 Oil Exchange Bldg Calgary Alberta Canada
Peter Bawden Drlg Ltd 810-A First St W Calgary Alberta Canada
Big Horn Drlg Ltd 6530 100th St Edmonton Alberta Canada
Brinkerhoff Drlg Co Ltd 1001 Mobil Oil Bldg Calgary Alberta Canada
Brown Drlg Ltd 10509 81st Ave Edmonton Alberta Canada
Cactus Drlg Corp Ltd Box 853 Calgary Alberta Canada
Calgary Oil Field Serv Ltd 133 Sixth Ave SE Rm 201 Calgary Alberta Canada
Can American Drlg Ltd 133 Sixth Ave E Calgary Alberta Canada
Can-Tex Drlg Co Ltd 239 Sixth Ave W Calgary Alberta Canada
Cascade Drlg Co Ltd 330 Ninth Ave W Calgary Alberta Canada
Central Leduc Drlg Co Ltd 224 Ninth Ave W Calgary Alberta Can
Commonwealth Drlg Co Ltd 122 Eighth Ave W Calgary Alberta Can
Coultis Drlg Ltd 1724 Suffolk St Calgary Alberta Canada
Dallas Drlg Co Ltd 1208 First Natl Bk Bldg Dallas Tex
Devon Drlg Co Ltd 703 Fifth St W Calgary Alberta Canada
Dominion Drlg Co Ltd 401 Petroleum Bldg Edmonton Alberta Canada
Double "A" Drlg Co Ltd 709 Eighth Ave W Calgary Alberta Canada
Duke Drlg Co Ltd 239 Eighth Ave W Calgary Alberta Canada
Eakle & Holder Drlg Co 116 Mulberry St Evansville Ind
Gardner Bros Drlg Co Inc 1718 Davis Bldg Dallas Tex
General Petroleums of Canada Ltd 224 Ninth Ave W Calgary Alberta Canada
Gustavson Drlg Co Ltd 203 Empire Bldg Calgary Alberta Canada
Hewgley Drlg Co 704 Wilco Bldg Midland Tex
Hi-Tower Drlg Co Ltd 400 Lancaster Bldg Calgary Alberta Canada
Hunter Drlg Ltd 602 Seventh Ave W Calgary Alberta Canada
Jennings Drlg Co (Alberta) Ltd 133 Sixth Ave SE Rm 201 Calgary Alberta Canada
Kenyon's Drlg Serv Co Ltd 10439 82nd Ave Edmonton Alberta Can
Lohmann-Johnson Drlg Co Ltd 208 Bamlett Bldg Calgary Alberta Can
M-H-O Drlg Co Box 297 Cut Bank Mont
Moore Drlg Co Ltd 502 Empire Bldg Calgary Alberta Canada
Oil Producers Ltd 222 Tegler Bldg Edmonton Alberta Canada
Parker Drlg Co of Canada Ltd 409 Eighth Ave W Calgary Alberta Canada
Patterson & Culver Box 92 Dunnville Ontario Canada
Pennant Drlg Ltd 108-A Eighth Ave W Calgary Alberta Canada
Regent Drlg Co Ltd Box 421 Edmonton Alberta Canada
Rine Drlg Co of Canada Ltd 534 8th Ave SW Calgary Alberta Can
Ryland Drlg Ltd 10318 82nd Ave Edmonton Alberta Canada
S & T Drlg Co Ltd 10852 82nd St Edmonton Alberta Canada
Teton Drlg Co Ltd Box 2068 Casper Wyo
Trident Drlg Co Ltd 830 Eighth St W Calgary Alberta Canada
Trinity Canadian Drlg Co 1001 F R Webster Bldg 237 Seventh Ave W Calgary Alberta Canada
Union Rotary Drlrs (Canada) Ltd 155 Wellington St Sarnia Ontario Canada
Wilrich Drlg Ltd 10584 107th St Edmonton Alberta Canada

Canadian Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALBERTA PROVINCE						
Brown Drlg Ltd	1	dsl	275	Crdwll S	—	5,000
	2	dsl	550	Natl 50	550	7,500
Hewgley Drlg Co	3	dsl	—	Emsco J-750	975	10,000
Lohmann-Johnson Drlg Co Ltd	1	dsl	550	"Oilwell" 66	550	7,500
	2	dsl	218	Unit U-15	500	8,500
Central						
Parker Drlg Co of Canada Ltd	1	dsl	615	"Oilwell" 76	750	11,000
	3	dsl	765	"Oilwell" 76	1005	12,000
	5	dsl	420	Natl 50	420	7,000
	11	dsl	400	Natl 50	500	6,500
	12	dsl	600	"Oilwell" 66	670	9,000
Northern						
Can-Tex Drlg Co Ltd	6	—	—	Emsco GA-500	—	8,000
	8	—	—	Natl T-25	—	5,500
	9	—	—	Crdwll OT	—	7,000
	12	—	—	Emsco GB-800	—	12,000
Southern						
Can-Tex Drlg Co Ltd	2	—	—	Crdwll RL	—	5,000
Airdrie						
Pennant Drlg Ltd	1	dsl	775	Unit U-15	775	8,500
Bede Creek						
Dominion Drlg Co Ltd	1	dsl	360	Natl T-32	280	5,000
Bentley						
Regent Drlg Co Ltd	28	dsl	500	Natl 50-A	520	7,000
Borland River						
Brinkerhoff Drlg Co Ltd	22	dsl	900	Natl 110	1450	15,000
Big Valley						
Moore Drlg Co Ltd	10	dsl	640	Emsco 350	640	6,500
Breton						
Arrow Drlg Co	8	dsl	250	Emsco GB-350	480	7,000
	19	dsl	250	Emsco GB-350	480	7,000
Calgary						
Devon Drlg Co Ltd	3	dsl	700	Emsco GB-500	500	9,500
General Pet of Canada Ltd	10	dsl	1400	Natl 80	1000	12,000
Carseland						
Cascade Drlg Co Ltd	7	dsl	—	Natl 50-A	—	7,500
Chancellor						
Hi-Tower Drlg Co Ltd	9	dsl	285	Crdwll D	300	5,000
Chard						
Big Horn Drlg Ltd	2	dsl	250	Crdwll L	180	3,500
	3	dsl	300	Crdwll L-350	300	4,500
Coultis Drlg Ltd	1	dsl	238	Ideco H-25-D	235	4,000
Precision Drlg Co Ltd	A	dsl	276	Ideco H-20-D	184	3,500
	8	dsl	276	Ideco 30	276	4,000
	9	dsl	276	Ideco H-25	276	4 000
Wilrich Drlg Ltd	4	dsl	220	Failing 2500	220	3,000/3½"
Cochrane						
Duke Drlg Co Ltd	6	dsl	850	Unit U-20	1386	13,500
Drayton Valley						
Cactus Drlg Corp Ltd	3	dsl	420	Natl T-32	280	6,000
Cascade Drlg Co Ltd	1	dsl	—	Natl 50	—	6,500
Gustavson Drlg Co Ltd	1	dsl	500	Natl 50	500	7,500
	3	dsl	275	Ideco H-40	300	6,500

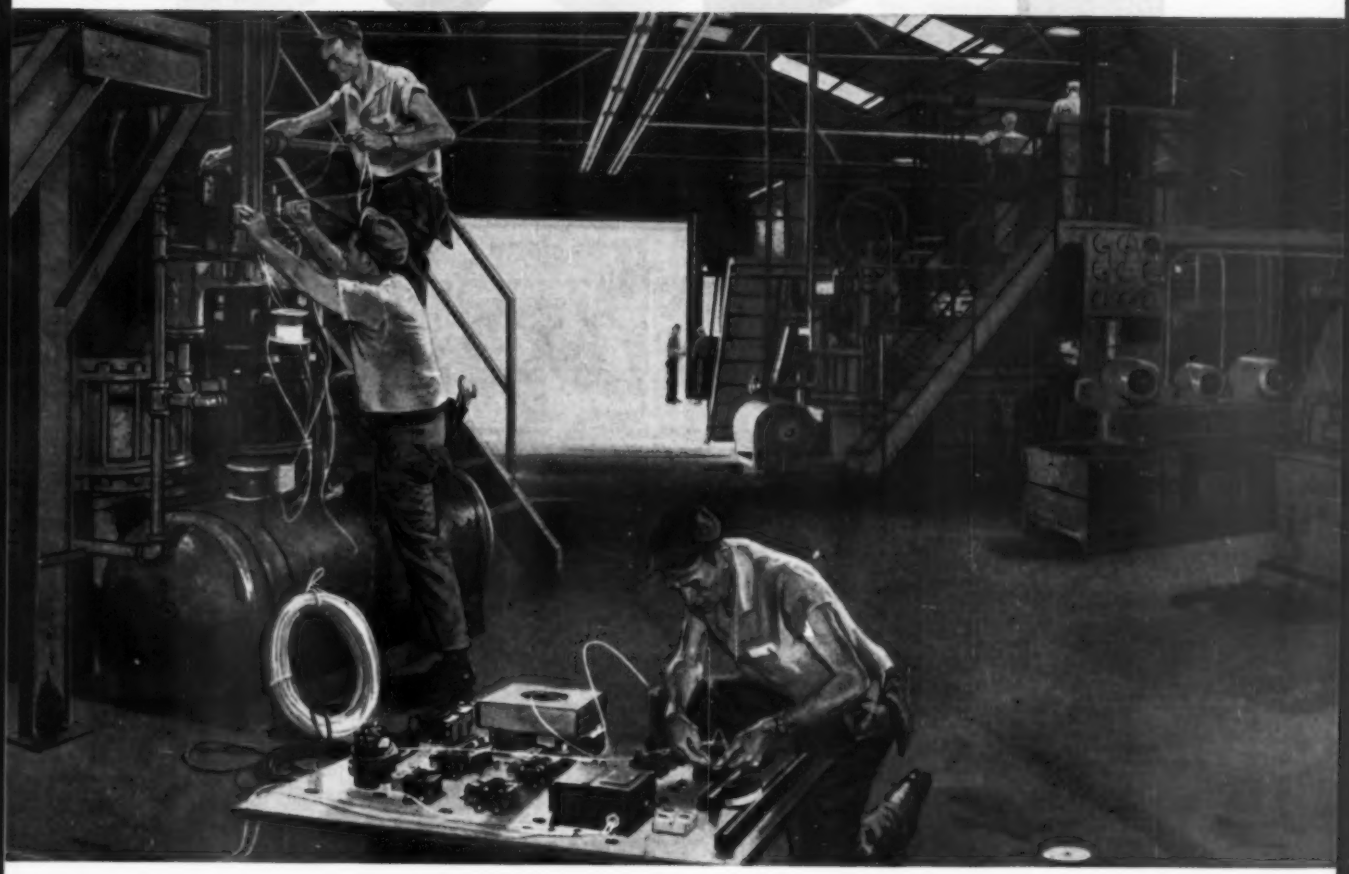
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Moore Drlg Co Ltd	8	dsl	640	Beth S-55	640	7,500
	9	dsl	640	Ideco 525	640	7,500
S & T Drlg Co Ltd	1	dsl	520	Natl 50-A	520	8,000
	2	dsl	440	Natl T-32	270	6,000
Edith Lake						
Regent Drlg Co Ltd	3	dsl	720	Brwstr N-55	520	8,000
Edmonton						
Calgary Oil Field Serv Ltd	2	dsl	120	Wisn Spr 38	180	10,000/2½"
Gardner Bros Drlg Co Inc	7	dsl	850	Natl 75	1000	12,000
Parker Drlg Co of Canada Ltd	4	dsl	400	Natl 50	500	6,500
Edson						
Arrow Drlg Co	21	dsl	1250	Emsco J-1250	1400	14,000
Brinkerhoff Drlg Co Ltd	21	dsl	850	Emsco GB-800	1269	13,500
Parker Drlg Co of Canada Ltd	9	dsl	765	Natl 125	1005	14,000
Pennant Drlg Ltd	6	dsl	1350	Unit U-40	1200	11,500
Trident Drlg Co Ltd	8	dsl	—	"Oilwell" 96	1920	15,000
Erskine						
Moore Drlg Co Ltd	5	dsl	600	Unit U-15	600	7,500
Fort McMurray						
Kenyon's Drlg & Serv Ltd	11	dsl	—	Crdwll 151	—	5,000/3½"
Precision Drlg Co Ltd	C	dsl	276	Natl T-20	276	5,000
Fort Vermilion						
Trident Drlg Co Ltd	10	dsl	—	Emsco GB-350	510	6,500
Grande Prairie						
Duke Drlg Co Ltd	8	dsl	500	Unit U-40	670	10,000
General Pet of Canada Ltd	5	dsl	800	Natl 80-B	1000	12,000
Gustavson Drlg Co Ltd	4	dsl	850	Natl 55	850	10,000
Parker Drlg Co of Canada Ltd	2	dsl	615	"Oilwell" 76	750	11,000
	7	dsl	600	Natl 55	670	9,000
Regent Drlg Co Ltd	9	dsl	750	Brwstr N-75	780	10,000
Trident Drlg Co Ltd	12	dsl	—	Unit U-15	640	7,500
Hay River						
Commonwealth Drlg Co Ltd	3	dsl	690	Natl 50	600	6,500
	17	dsl	630	Emsco GB-350	720	6,000
High Level						
Dominion Drlg Co Ltd	3	dsl	600	Natl T-32	320	5,000
High River						
Trident Drlg Co Ltd	9	dsl	—	"Oilwell" 76	960	10,000
Hines Creek						
Arrow Drlg Co	4	dsl	500	Emsco GB-350	500	7,000
Innisfail						
Brinkerhoff Drlg Co Ltd	1	dsl	625	Emsco GB-500	846	10,000
Can-Tex Drlg Co Ltd	3	—	—	Emsco GB-800	—	12,000
General Pet of Canada Ltd	11	dsl	1400	Natl 80-B	1150	12,000
Hi-Tower Drlg Co Ltd	1	dsl	525	"Oilwell" 66	550	8,000
	10	dsl	755	"Oilwell" 76	800	12,000
Pennant Drlg Ltd	3	dsl	600	Crdwll O	540	8,500
	4	dsl	1000	Crdwll O	650	9,500
S & T Drlg Co Ltd	3	dsl	900	Natl 55	900	9,000
James River						
Jennings Drlg Co (Alberta) Ltd	1	dsl	225	Beth C-50	225	6,500/3½"
Joffre						
Brinkerhoff Drlg Co Ltd	15	dsl	370	Natl 50-A	450	8,500
Kaybob						
Brinkerhoff Drlg Co Ltd	18	dsl	625	Emsco GC-500	846	10,000
Keg River						
Commonwealth Drlg Co Ltd	27	dsl	870	Natl 50-A	660	9,000
	28	dsl	920	Natl 55	1000	10,000
Duke Drlg Co Ltd	2	dsl	650	Natl 50	650	8,000
Keystone						
Peter Bawden Drlg Ltd	1	dsl	415	Natl T-32	275	5,500
Regent Drlg Co Ltd	1	dsl	260	Brwstr N-4	260	6,000
Rine Drlg Co of Canada Ltd	2	dsl	590	Brwstr N-55	720	8,500
Ryland Drlg Ltd	4	dsl	450	Emsco 350	475	7,000
Kinuso						
Can-American Drlg Ltd	3	dsl	750	Natl 80-B	1645	10,000
Lac La Biche						
Dominion Drlg Co Ltd	4	dsl	600	Emsco GB-250	300	5,000
Lacombe						
General Pet of Canada Ltd	6	dsl	400	Natl 50-A	500	7,000
Leduc						
Wilrich Drlg Ltd	6	dsl	300	Unit U-34	300	6,000
Lloydminster						
Oil Producers Ltd	3	dsl	100	Crdwll K	142	3,000
Longview						
Duke Drlg Co Ltd	6	dsl	700	Unit U-20	1386	13,500
Loon Lake						
Commonwealth Drlg Co Ltd	7	dsl	750	Natl 50	530	6,500
Manning						
Trident Drlg Co Ltd	14	dsl	—	"Oilwell" 76	960	10,000
Milk River						
Hi-Tower Drlg Co Ltd	7	dsl	525	"Oilwell" 66	550	8,000
Nanton						
Trident Drlg Co Ltd	4	dsl	—	Natl 100	1200	13,000
Nordegg						
General Pet of Canada Ltd	7	dsl	1400	Natl 80-B	1300	13,000
Parker Lake						
Double-A Drlg Co Ltd	2	dsl	800	Ideco H-525	600	8,000
Peace River						
Cascade Drlg Co Ltd	4	dsl	—	Natl 50A	—	7,500
Hi-Tower Drlg Co Ltd	3	dsl	525	"Oilwell" 66	550	8,000
Parker Drlg Co of Canada Ltd	6	dsl	420	"Oilwell" 52-T	420	6,500
	8	dsl	400	Natl 50	500	6,500
	10	dsl	400	Natl 50-A	500	7,000
Regent Drlg Co Ltd	26	dsl	260	Ideco H-40	260	6,000
Pembina						
Peter Bawden Drlg Ltd	5	dsl	440	Natl T-32	270	5,500
Brinkerhoff Drlg Co Ltd	16	dsl	370	Emsco GA-350	450	7,500
Cascade Drlg Co Ltd	3	dsl	—	Natl 50	—	6,500
	8	dsl	—	Natl 50	—	6,500
	9	dsl	—	Natl T-32	—	5,500
	10	dsl	—	Natl 50	—	6,000
Commonwealth Drlg Co Ltd	10	dsl	550	Ideco H-35D	300	6,500
General Pet of Canada Ltd	14	dsl	350	Crdwll OA	500	6,500
Hi-Tower Drlg Co Ltd	4	dsl	350	Natl 50	450	6,500
	8	dsl	570	Unit U-15	600	8,000
Ryland Drlg Ltd	1	dsl	600	Emsco 450	640	7,500
	2	dsl	670	Natl 50	690	7,500
Trident Drlg Co Ltd	1	dsl	—	"Oilwell" 64B	640	5,000
	3	dsl	—	"Oilwell" 64B	640	5,000
Petitot River						
Regent Drlg Co Ltd	2	dsl	520	Brwstr N-55	520	8,000
Pincher Creek						
Brinkerhoff Drlg Co Ltd	19	dsl	850	Emsco A-800	1269	14,000
Commonwealth Drlg Co Ltd	26	dsl	1275	Natl 80-B	1410	12,000
Priddis						
Commonwealth Drlg Co Ltd	21	dsl	1250	Ideco 7-11	900	10,500
Princess						
Rine Drlg Co of Canada Ltd	1	dsl	380	Brwstr N-45	350	6,500
Red Deer						
Peter Bawden Drlg Ltd	6	dsl	722	Unit U-36A	722	8,500
Calgary Oil Field Serv Ltd	1	dsl	120	Wisn Spr 38	180	10,000/2½"
Can-Tex Drlg Co Ltd	5	—	—	"Oilwell" 66	—	8,000
Commonwealth Drlg Co Ltd	8	dsl	690	Brwstr N-7	600	8,000
General Pet of Canada Ltd	3	dsl	425	Natl 50-A	650	7,500
	4	dsl	500	Natl 50-A	650	7,500
Moore Drlg Co Ltd	1	dsl	1000	Unit U-40	1000	10,000
	2	dsl	600	Emsco 450	640	7,000
Trident Drlg Co Ltd	13	dsl	—	"Oilwell" 66	640	7,000
Red Earth						
Commonwealth Drlg Co Ltd	11	dsl	260	Ideco H-40D	300	5,500
	16	dsl	800	Emsco GB-350	720	7,000
Gustavson Drlg Co Ltd	5	dsl	420	Natl T-32	275	6,500
Hi-Tower Drlg Co Ltd	5	dsl	350	Natl 50	450	5,000
Rocky Mountain House						
Can-Tex Drlg Co Ltd	10	—	—	Emsco J-1100	—	15,000
General Pet of Canada Ltd	17	dsl	1400	Natl 55	1050	10,000
	19	dsl	435	Natl T-32	175	5,500
Sedgewick						
Big Horn Drlg Ltd	1	dsl	300	Crdwll S 350	300	5,000
Simonette Valley						
Cascade Drlg Co Ltd	12	dsl	—	Natl 80-B	—	14,000
Commonwealth Drlg Co Ltd	19	dsl	735	Natl 50-A	790	9,500
Smoky Lake						
Moore Drlg Co Ltd	6	dsl	400	Emsco 300	300	6,000
Stettler						
Regent Drlg Co Ltd	30	dsl	260	Ideco H-40	260	6,000
Sundre						
Cascade Drlg Co Ltd	14	dsl	—	Unit U-20	—	14,000
Commonwealth Drlg Co Ltd	23	dsl	905	Emsco GC-500	800	9,500
Duke Drlg Co Ltd	7	dsl	850	Unit U-20	1386	13,500
General Pet of Canada Ltd	15	dsl	1400	Natl 55	1050	10,000
Pennant Drlg Ltd	2	dsl	1155	Brwstr N-7	755	10,000
Regent Drlg Co Ltd	6	dsl	750	Brwstr N-75	780	10,000
	7	dsl	1200	Natl 125	1500	15,000
Trident Drlg Co Ltd	7	dsl	—	"Oilwell" 76	960	10,000
Swan Hills						
Commonwealth Drlg Co Ltd	9	dsl	1020	Ideco 700	940	10,000
Hi-Tower Drlg Co Ltd	6	dsl	755	"Oilwell" 76	800	12,000
Valleyview						
Cascade Drlg Co Ltd	17	dsl	—	Natl 75	—	12,000
General Pet of Canada Ltd	16	dsl	1050	Natl 55	1150	10,000
Virginia Hills						
Regent Drlg Co Ltd	8	dsl	750	Brwstr N-75	780	10,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Warner						
Arrow Drlg Co	6	dsl	250	Emsco GB-350	350	7,000
Waterton						
Commonwealth Drlg Co Ltd	1	dsl	1350	Natl 110	1500	14,000
Westward Ho						
Can-Tex Drlg Co Ltd	4	—	—	Crdwll OC	—	8,000
	7	—	—	"Oilwell" 64B	—	7,500
Whitecourt						
Arrow Drlg Co	26	dsl	975	Emsco GB-800	1200	13,000
Peter Bawden Drlg Ltd	2	dsl	750	Natl 55	750	10,000
Duke Drlg Co Ltd	9	dsl	500	Unit U-15	650	8,500
General Pet of Canada Ltd	18	dsl	1400	Natl 80-B	1150	12,000
Moore Drlg Co Ltd	7	dsl	960	Beth S-55	640	7,500
Regent Drlg Co Ltd	25	dsl	750	Brwstr N-75	780	10,000
Willesden Green						
Jennings Drlg Co (Alberta) Ltd	2	dsl	225	Beth G-50	225	6,500/3½"
BRITISH COLUMBIA PROVINCE						
Dallas Drlg Co Ltd	1	dsl	625	Emsco GB-500	750	9,500
	2	dsl	578	Emsco GB-500	560	8,000
	3	dsl	500	Emsco GB-350	495	7,000
	4	dsl	500	Emsco GB-350	560	7,000
Blueberry						
Brinkerhoff Drlg Co Ltd	20	dsl	370	Natl 50-A	450	8,500
Boundary Lake						
Commonwealth Drlg Co Ltd	15	dsl	800	Brwstr N-7	600	8,000
Dawson Creek						
Cascade Drlg Co Ltd	5	dsl	—	Natl 50-A	—	7,500
	11	dsl	—	Crdwll D	—	5,500
Trinity Canadian Drlg Co	5	dsl	1250	Emsco A-800	1150	15,000
Ft. Nelson						
Arrow Drlg Co	7	dsl	600	Emsco GC-500	700	9,000
Brinkerhoff Drlg Co Ltd	14	dsl	370	Emsco GB-500	600	8,500
Trident Drlg Co Ltd	6	dsl	—	Emsco 500	640	8,500
Ft. St. John						
Cascade Drlg Co Ltd	2	dsl	—	Wisn Roadair	—	9,200
Commonwealth Drlg Co Ltd	20	dsl	1270	Ideco 7-11	900	10,500
Devon Drlg Co Ltd	1	dsl	700	Emsco GA-500	500	9,500
	2	dsl	300	Emsco GA-350	350	7,500
Regent Drlg Co Ltd	5	dsl	720	Brwstr N-7	520	8,000
	24	dsl	720	Brwstr N-7	520	8,000
Trinity Canadian Drlg Co	1	dsl	995	Emsco GC-500	770	10,000
	3	dsl	720	Emsco 350	670	7,000
	4	dsl	990	Natl 80-B	990	12,000
	7	dsl	875	Emsco GC-500	720	10,000
Halfway River						
Dominion Drlg Co Ltd	2	dsl	580	Natl 50-A	450	6,500
Milligan Creek						
Wilrich Drlg Ltd	2	dsl	300	Natl T-12	300	4,000/3½"
Mulligan Lake						
Commonwealth Drlg Co Ltd	22	dsl	750	Natl 50	530	6,500
MANITOBA PROVINCE						
St. Lazare						
Can American Drlg Ltd	6	dsl	275	Natl T-12	260	3,000
Routledge						
Commonwealth Drlg Co Ltd	18	dsl	260	Ideco H-25D	300	4,500
Virden						
Coultis Drlg Ltd	2	dsl	245	Wisn Mogul	245	4,000
	3	dsl	200	Wgnr Mrhse TD-2	200	3,500/3½"
ONTARIO PROVINCE						
Kent						
Union Rotary Drlrs (Can) Ltd	1	gas-LPG	200	Natl 40	180	4,000
Prince George						
Eakle & Holder Drlg Co	4	dsl	300	Natl T-20	300	5,500
SASKATCHEWAN PROVINCE						
(Southeastern)						
Double-A Drlg Co Ltd	3	dsl	300	Ideco H-40	265	6,000
General Pet of Canada Ltd	1	dsl	250	Natl 50	525	6,500
	2	dsl	250	Unit U-34	250	4,800
	8	dsl	250	Natl T-25	250	5 000
	9	dsl	375	Natl T-25	250	5,500
	12	dsl	250	Natl T-20	250	4,600
	20	dsl	275	Emsco GB-250T	275	5,000
	21	dsl	250	Natl T-20	185	4,600
(Southern)						
Can-Tex Drlg Co Ltd	1	—	—	Crdwll RL	—	5,000
Allan						
Can American Drlg Ltd	7	dsl	260	Natl T-20	200	4,500
Arlington						
Peter Bawden Drlg Ltd	3	dsl	270	Crdwll S	180	4,500
Carlyle						
Hunter Drlg Ltd	3	dsl	450	Crdwll	260	6,000
Carnduff						
Gustavson Drlg Co Ltd	2	dsl	500	Natl T-32	250	6,500
Moore Drlg Co Ltd	3	dsl	320	Brwstr N-4	190	4,000
Precision Drlg Co Ltd	6	dsl	550	Ideco H-30-D	276	5,000
Regent Drlg Co Ltd	22	dsl	260	Brwstr N-4	260	6,000
Coleville						
Precision Drlg Co Ltd	B	dsl	276	Ideco H-30	276	5,000
Estevan						
Brinkerhoff Drlg Co Ltd	12	dsl	200	Natl T-32	300	6,000
Lohmann-Johnson Drlg Co Inc	5	dsl	300	Crdwll S	440	4,500
Regent Drlg Co Ltd	4	dsl	260	Brwstr N-4	260	6,000
	23	dsl	260	Brwstr N-4	260	6,000
Teton Drlg Co Ltd	1	dsl	520	Emsco GB-250	360	6,500
Festerton						
Precision Drlg Co Ltd	E	dsl	550	Ideco 525	550	7,500
Frobisher						
Can American Drlg Ltd	2	dsl	650	Natl T-55	975	7,500
Commonwealth Drlg Co Ltd	5	dsl	260	Emsco GA-250T	310	5,000
Regent Drlg Co Ltd	29	dsl	260	Brwstr N-4	260	6,000
Instow						
Precision Drlg Co Ltd	D	dsl	276	Brwstr N-4	276	5,000
Manor						
Commonwealth Drlg Co Ltd	6	dsl	690	Ideco M-750	600	7,000
Maryfield						
Cardinal Drlg Co (Bismarck)	—	dsl	320	Natl T-20	320	5,000
Midale						
Can American Drlg Ltd	5	dsl	375	Natl T-32	320	5,000
Cascade Drlg Co Ltd	6	dsl	—	Natl T-20	—	4,500
	16	dsl	250	Unit U-34	250	4,500
Moosomin						
Peter Bawden Drlg Ltd	4	dsl	220	Crdwll RL	205	4,500
Oxbow						
Commonwealth Drlg Co Ltd	4	dsl	260	Ideco H-40D	300	6,000
Double-A Drlg Co Ltd	1	dsl	300	Ideco H-30	265	4,500
Kenyon's Drlg & Serv Ltd	12	dsl	—	Frnks Comet 658	—	5,000
Ryland Drlg Ltd	3	dsl	320	Natl T-32	320	6,000
Rocanville						
Precision Drlg Co Ltd	1	dsl	276	Ideco H-30-D	276	5,000
Roncott						
Regent Drlg Co Ltd	27	dsl	260	Brwstr N-4	260	6,000
Steelman						
Commonwealth Drlg Co Ltd	12	dsl	260	Natl T-32	300	5,500
	13	dsl	630	Emsco GA-350	720	6,500
	14	dsl	580	Ideco H-40D	660	5,500
	25	dsl	425	Unit U-34D	300	5,500
Hunter Drlg Ltd	1	dsl	450	Crdwll	260	6,000
Moore Drlg Co Ltd	4	dsl	330	Emsco 300	300	5,000
Weyburn						
Can American Drlg Ltd	1	dsl	350	Natl T-32	275	5,000
Central Leduc Drlg Co Ltd	1	dsl	500	Natl 50	500	6,500
	2	dsl	285	Crdwll TR 66	245	5,000
Commonwealth Drlg Co Ltd	2	dsl	550	Natl 50	420	6,500
	24	dsl	520	Natl 50	600	6,000
Hunter Drlg Ltd	2	dsl	275	Crdwll	260	6,000
Wynyard						
Can American Drlg Ltd	4	dsl	260	Natl T-20	260	4,000

Canadian Cable Tools

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top of Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALBERTA						
Lloydminster						
Oil Producers Ltd	1	gaso	69	—	4000	Crdwll M
	2	gaso	87	—	3000	Crdwll Q
BRITISH COLUMBIA						
Monkman Pass						
M-H-O Drilling Co	6	dsl	140	3000	4500	B Erie 36-L
ONTARIO						
Haldimand						
Patterson & Culver	2	gas	60	1500	2000	B Erie 24-L
	3	gas	60	1500	2000	B Erie 24-L
Norfolk						
Patterson & Culver	1	gas	80	2500	3500	B Erie 28-L

REED doubles production of Flash Welded Tool Joints!



REED is installing a complete new additional system for flash welding tool joints to drill pipe, and for two very good reasons. First, your ever-increasing requests for Reed *Flash Welded* Tool Joints far exceed our present production capacity, and second, the enviable performance record of Reed *Flash Welded* Tool Joints . . .

There has never been a failure in the weld of a Reed Flash Welded Tool Joint in field use throughout the world!

Reed is the only manufacturer of flash welded tool joints that can make the foregoing statement. This unexcelled record of Reed *Flash Welded* Tool Joints is a direct result of Reed's more than twenty-five years of leadership experience in the manufacture of all types of tool joints. Reed has successfully produced approximately *two million pairs* of tool joints.

Installation of this second giant resistance welder, custom-engineered to Reed's specifications, will double Reed's capacity to produce flash welded tool joints and make delivery to your requirements. Every precaution will be taken to insure that this second machine will maintain Reed's record of never having had a failure in a weld.

Whatever your requirements in standard or special tool joints, ask the leader—ask your Reed man!

REED ROLLER BIT COMPANY HOUSTON 1, TEXAS

7222

SOME CONTRACT RIGS IN FOREIGN SERVICE

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALASKA						
Kenai Peninsula						
Coastal Drlg Co	3	dsl	1000	Emsco A-800	1650	13,000
BRITISH HONDURAS						
Kerr-McGee Oil Ind Inc	14	dsl	695	Natl 50	630	9,000
	50	dsl	1000	Natl 55	770	10,000
COLOMBIA						
Drlg & Expl Co Inc	—	dsl	—	"Oilwell" 96	1500	18,000
CUBA						
Punta Alegre						
C G Glasscock Drlg Co	3	dsl	1500	Emsco J-1250	—	17,000
DOMINICAN REPUBLIC						
Comet Drlg Co	2	dsl	1000	Natl 75	750	10,000
HOLLAND						
Drilvo	—	dsl	—	Franks	700	7,000
	—	dsl	—	Natl 50	750	8,500
	—	dsl	—	Natl 75	1050	9,500
INDIA						
Southeastern Asia Drlg Co	26	dsl	1000	Natl 55	825	10,000
ITALY						
Drilvo	—	dsl	—	Natl 100	1200	13,000
Abruzzo						
Delta Overseas Drlg Co	2	dsl	260	Ideco H-30	300	4,500
Romagna						
Delta Overseas Drlg Co	1	dsl	900	Ansaldo 2000	600	7,000
JORDAN						
Parker Drlg Co	46	gas	—	Natl L-75	700	10,000
LIBYA						
Camdrill International Inc	—	dsl	255	Ideco H-30-D	300	4,500
	2	dsl	1000	Natl 110	2400	13,000
Delta Drlg Co	1	dsl	1250	Emsco A-800	900	11,000
MEXICO						
Del Mar Drlg Co	3	gas	690	Natl 75	750	10,500
NIGERIA						
Drilvo	—	dsl	—	Natl 80-B	1500	14,000
PAKISTAN						
Southeastern Asia Drlg Co	24	dsl	1200	"Oilwell" 96	1600	18,000
	27	dsl	1000	Natl 55	825	10,000
SICILY						
Armerina						
Delta Overseas Drlg Co	4	dsl	900	Emsco 800	900	11,000
Grande						
Delta Overseas Drlg Co	3	dsl	500	Emsco GB-500	500	8,500
TURKEY						
Drlg & Expl Co Inc	—	dsl	—	Emsco GB-500	1050	7,500
	—	dsl	—	Natl 80-B	1500	14,000
Clyde Hall Drlg Co Inc	8	dsl	600	Beth M-58	600	9,000
VENEZUELA						
Reading & Bates Co de Venezuela	2	dsl	1680	Natl 110	1800	15,000
Borinas						
Perforaciones Delta CA (Caracas Venezuela)	10	dsl	260	Crdwll O	450	7,500
(Eastern)						
Perforaciones Delta CA (Caracas Venezuela)	1	dsl	260	Ideco H-40-D	400	6,500
	2	dsl	260	Ideco H-40-D	400	6,500
	3	dsl	260	Failing 2066	—	—
	5	stm	1200	Emsco UBLS	1690	15,000
	6	dsl	260	Ideco H-40-D	400	6,500
	7	dsl	260	Ideco H-30-D	300	4,500
Gulf of Paria						
Perforaciones Delta CA	12	dsl	1560	Emsco J-1250	1250	15,000
Lake Maracaibo						
Perforaciones Delta CA	13	dsl	1040	Emsco J-1250	1250	15,000
	14	dsl-elec	2000	Emsco ECB	1200	15,000
	15	dsl-elec	2000	Emsco ECB	1200	15,000
	16	dsl-elec	2000	Emsco ECB	1200	15,000
(Western)						
Perforaciones Delta CA (Caracas Venezuela)	4	dsl	260	Ideco H-40-D	400	6,500
	8	dsl	600	Emsco G-500	500	8,000
	9	dsl	1000	Emsco GB-800	900	12,000
	11	dsl	130	Natl T-12	120	2,500

U.S. OFFSHORE RIG LOCATOR

Some abbreviations. To provide the greatest amount of information in a compact listing, it is necessary to employ some abbreviations. Manufacturers' names are indicated in the introduction of the RIG LOCATOR. Here is a list of abbreviations employed in the offshore section for operators and operator groups:

Operators

Anderson-Prichard—Anderson-Prichard Oil Corporation.
Ark Fuel —Arkansas Fuel Oil Corporation.
CATC — Continental Oil Company, The Atlantic Refining Company, Tidewater Oil Company, and Cities Service Oil Company.
Calco — The California Company.
Gulf — Gulf Oil Corporation.
Humble — Humble Oil and Refining Company.
Kermac — Kerr-McGee Oil Industries, Inc.
M-C-N — Magnolia Petroleum Company, Continental Oil Company and Newmont Oil Company.
Magnolia —Magnolia Petroleum Company.
Phillips — Phillips Petroleum Company.
Richfield — Richfield Oil Corporation.
Shell — Shell Oil Company.
Std Cal — Standard Oil Company of California.
Superior — The Superior Oil Company of California.
Texaco — The Texas Company.

CALIFORNIA

Owner's Name, Address	Rig, Barge Name or Number	Operator Drlg For	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Humble Oil & Ref Co	SM-1	Humble	Calif Area	64–243	dsl engine	Hopper	300	175	3,500
Marex Inc	"PCS Exploit"	Texaco	—	150	dsl engine	Howard-Turner	175	175	1,500
	"Labusca"	—	—	—	dsl engine	Howard-Turner	165	165	1,500
	"Sandab V"	E W Pauley	—	150	dsl engine	Howard-Turner	175	175	1,500
Richfield Oil Corp	"La Ciencia"	Richfield	S Santa Barbara	186	dsl engine	Hopper Hoist	165	165	1,500
	"Rincon"	Richfield	Point Gorda	81	dsl engine	Emsco 160	400	300	4,000
Std Oil Co of Calif	"Western Explorer"	—	(various)	—	dsl engine	Wgnr Mrhse	200	200	3,500

TEXAS

Owner's Name, Address	Rig, Barge Name or Number	Operator Drlg For	Location—Designation	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
MOBILE DRILLING BARGES									
Zapata Off-Shore Co	Rig 2 "Scorpion"	*	Galveston	—	dsl engine	"Oilwell" 96	1850	1850	16,000
Movible Offshore Co	Rig 2	Shell	Mustang Is Blk 888	80	dsl-elec	Natl 1625	1250	2000	20,000+
PLATFORM-TENDER DRILLING UNITS									
Coastal-Marine Drlg & Constr Corp	"Howard S Cole Jr"	(Awaiting new location)	Beaumont	—	dsl-elec	Ideco E-2500	1200	2500	20,000+
Zapata Off-Shore Co	Rig 1 "Nola"	*	Galveston	—	dsl engine	Natl 130	1400	1850	15,000
SUBMERSIBLE BARGES									
Layton Brown Drlg Co Inc	Bge 2	Brown	Aransas Bay ST 245	12	dsl engine	Brwstr N-7	700	900	10,000
	Bge 4	Ark Fuel	Corpus Christi Bay—ST 9	13	dsl engine	"Oilwell" 96	1000	1800	17,000

LOUISIANA

MOBILE DRILLING BARGES									
Barnwell Offshore Inc	"Mister Cap"	Barnwell	Main Pass Blk 25	90	dsl-elec	Ideco E-2500	2500	2000	20,000
Continental Marine Expl Co	"Carter Mart"	Texaco	S Timbalier Blk 16	35	dsl engine	Wlsn 66	2400	2800	25,000
Delta Marine Drlg Co	Rig 2 "Chris Zeppa"	ODECO	W Cameron Blk 66	33	dsl engine	Ideco Bg Gnt	1600	1950	15,000
C G Glasscock Drlg Co	Rig 12 "Mr Gus II"	CATC	W Delta Blk 70	138	dsl-elec	Natl 160-E	1950	3900	25,000
Humble Oil & Ref Co	Rig 47	*	—	—	dsl-elec	Emsco GB-250TS	260	500	5,000
Kerr-McGee Oil Ind Inc	Rig 40	Pure	Eugene Is Blk 32	15	dsl engine	Emsco J-1600	1150	1250	16,000
	Rig 44	Kermac	Ship Shoal Blk 28	20	dsl engine	Ideco Hydrair 1350-S	1550	1760	20,000
	Rig 45	*	—	—	dsl engine	"Oilwell" 96-S	1150	1100	16,000
	Rig 46	Pure	Vermilion Blk 38	40	dsl-elec	Emsco EDA-460	1250	1250	20,000
	Rig 47	Phillips	S Timbalier Blk 28	50	dsl-elec	Emsco EDA-460	1250	1250	20,000
Louisiana-Delta Offshore Corp	"Delta No. 1"	Shell	Main Pass Blk 27	25	dsl-elec	Unit U-1220	1370	1400	20,000
	"Louisiana"	—	—	70	dsl-elec	Unit U-1220	1370	2000	20,000
Marine Drlg Inc	Rig 10	Mecom	W Cameron Blk 1134	31	dsl-elec	Emsco EDA	1600	1700	18,000
Noble Drlg Co	— S-55	Calco	Main Pass Blk 41	53	dsl-elec	—	—	—	—
Ocean Drlg & Expl Co	"St Louis"	Shell	South Pass Blk 27	35	dsl-elec	Emsco ECB	1200	1000	15,000
	"Mr Charlie"	Shell	Vermilion Blk 110	40	dsl-elec	Emsco EDA	1500	1000	20,000
	"Margaret"	Shell	E Cameron Blk 82	55	dsl-elec	Emsco EDES	1500	1000	20,000
Penrod Drlg Co	Bge 51 "J M Woodruff"	Calco	W Delta Blk 30	38	dsl-elec	Emsco EDES	1600	2450	20,000
	Bge 50 "W O Woodward"	—	Eugene Is	—	dsl-elec	Emsco EDES	1600	2450	20,000
Reading & Bates Offshore Drlg Co	"C E Thornton"	(under construction)	—	—	dsl engine	Natl 110	1220	2250	18,000
Rowan Drlg Co Inc	Bge 19	Calco	Bay Marchand Blk 2	22	dsl-elec	Unit U-1220-E	2250	2100	20,000
Service Contr Inc	—	Calco	Main Pass Blk 69	10½	dsl engine	—	—	—	—
Zapata Off-Shore Co	Rig 3 "Vinegarroon"	Zapata	Vermilion Blk 86	41	dsl engine	"Oilwell" 96	2080	2150	18,000

*Reported Idle February 1, 1958.

PLATFORM-TENDER DRILLING UNITS									
Booker Drlg Co	Rig 3	Humble	W Delta Blk 30	45-60	—	—	—	—	—
Deepwater Expl Co	"Deepwater No 1"	Anderson-Prichard	Ship Shoal Blk 174	70	dsl-elec	Natl 130-E	1200	2400	16,000
Delta Drlg Co	Rig 16	Humble	Grand Is Blk 16	35	dsl engine	Beth MC-950	1400	1200	15,000
	Rig 35	Humble	Pelican Is	35	dsl engine	Emsco J-1100	1200	1200	15,000
	Rig 37	Humble	Pelican Is	35	dsl engine	Beth MC-950	1400	900	15,000
Delta Marine Drlg Co	Rig 1 "Joseph Zeppa"	M-C-N	W Cameron Blk 110	45	dsl-elec	Emsco JB-1250	1600	1600	15,000
Hawkins-Wilkins Prod Co	Rig 2	Humble	Eugene Is Blk 77	38	dsl engine	Ideco PR-1050	900	1320	16,000

PLATFORM-TENDER DRILLING UNITS — (Continued)

Owner's Name, Address	Rig, Barge Name or Number	Operator Drlg For	Location—Designation	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Humble Oil & Ref Co	Rig 36	Humble	W Delta Blk 30	45–60	dsl engine	Emsco J-1250	1000	1000	15,000
	Rig 46	Humble	Grand Is Blk 18	45–60	dsl engine	Emsco J-1400	1000	1000	16,000
	Rig 49	Humble	Grand Is Blk 16	45–60	dsl engine	Emsco J-1400	1000	1000	16,000
	Rig 53	Humble	Grand Is Blk 16	45–60	dsl engine	Ideco M-2500	1000	1000	16,000
	Rig 54	Humble	S Timbalier Blk 54	45–60	dsl engine	Ideco M-2500	1000	1000	16,000
Kerr-McGee Oil Ind Inc	Bge 16 "Kermac I"	*	—	—	dsl engine	Natl 100	900	900	12,500
	Bge 39 "D. V. IV"	*	—	—	dsl engine	Natl 125	1800	1200	16,000
	Rig 43 "Kermac II"	*	—	—	dsl engine	Emsco J-1000	1350	1730	14,000
	Rig 48 "Kermac III"	CATC	Vermilion Blk 119	65	dsl-elec	Emsco EDA-460	2625	2625	16,000
Llano Drlg Co	Rig 6 "Clayton G Dorn"	Gulf	S Timbalier Blk 21	35	dsl engine	"Oilwell" 96	1800	2475	20,000
Loffland Bros Co	Rig 1 & Rig 148 S-25	Calco	W Delta Blk 30	39	dsl engine	Natl 125	1500	1850	18,000
	Rig 133 S-26	Calco	Main Pass Blk 69	22	dsl engine	Unit U-30	1200	1800	15,500
Magnolia-Continental-Newmont	Rig 34 Bge 1	M-C-N	S Pelto Blk 12	40	dsl engine	Natl 125	1040	1040	15,000
	Rig 39 Bge 2	—	—	—	dsl engine	Natl 125	1240	1300	15,000
	Rig 44 Bge 5	—	—	—	dsl engine	Emsco JB-1250	1040	1040	15,000
	Rig 45 Bge 6	M-C-N	Eugene Is Blk 126	40	dsl engine	Natl 125	1040	1080	15,000
	Rig 47 Bge 3	M-C-N	Ship Shoal Blk 113	40	dsl engine	Natl 125	1040	1040	15,000
	Rig 48 Bge 4	M-C-N	E Cameron Blk 64	45	dsl engine	Emsco JB-1250	1040	1040	16,000
	Rig 57 Bge 7	M-C-N	Ship Shoal Blk 72	35	dsl engine	Natl 130	1040	1040	16,000
Magnolia Petroleum Co	Rig 61 "Gulf Coast Bge 2"	Magnolia	W Cameron Blk 17	18	dsl-elec	Natl	1250	3500	16,000
Movible Offshore Co	Rig 1	Humble	S Timbalier Blk 54	69	dsl engine	Natl 125	1200	1200	16,000
Nicklos Drlg Co	Rig 13 "Ernie Miller"	*	—	—	dsl engine	Natl 125	1400	—	17,000
	Rig 17 "J C Craig"	CATC	W Delta	45	dsl engine	Natl 130	1400	—	17,000
Noble Drlg Co	— S-21	Calco	W Delta Blk 30	42	dsl engine	—	—	—	—
	— S-22	Calco	Vermilion Blk 164	98½	dsl engine	—	—	—	—
	— S-23	Calco	Bay Marchand Blk 2	43	dsl engine	—	—	—	—
Penrod Drlg Co	Rig 10 "Eagle"	Gulf	S Timbalier Blk 135	186	dsl engine	Natl 130	1500	1520	18,000
Phillips Pet Co	Rig 40	Phillips	Bay Marchand Blk 5	12	dsl engine	Natl 125	1350	1200	16,000
Reading & Bates Offshore Drlg Co	"J W Bates"	CATC	E Cameron Blk 72	100	dsl engine	Natl 130	2000	3000	20,000+
	"Geo M Reading"	CATC	Vermilion Blk 115	100	dsl engine	Natl 130	2000	3000	20,000+
Rowan Drlg Co Inc	Rig 30	Humble	W Delta Blk 30	45–60	dsl engine	Emsco A-1500	2400	2000	18,000
Salt Dome Prod Co	Rig 10 "Pelican"	Gulf	Timbalier Blk 20	30	dsl engine	Beth 1013	1500	1500	16,000

INLAND BARGE PLATFORM

Magnolia Pet Co	Rig 52 "Gulf Coast Bge 1"	*	—	—	dsl engine	Natl 125	1560	1560	15,000

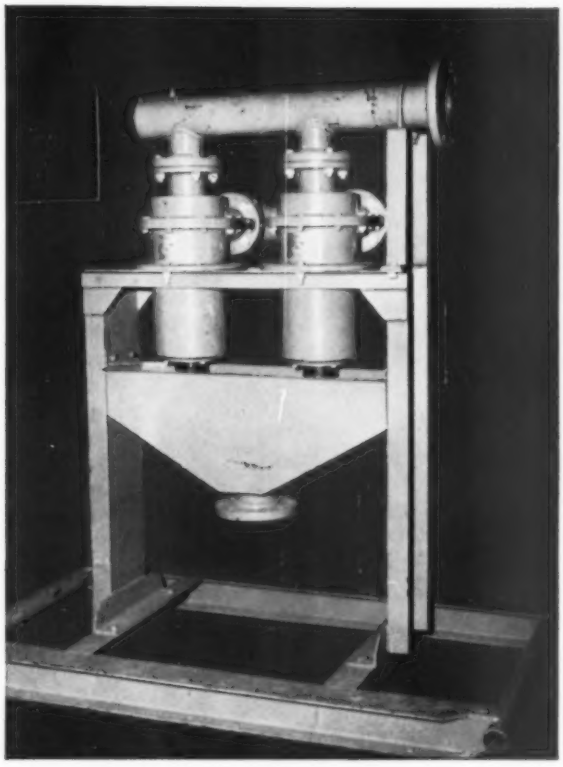
SELF-CONTAINED PLATFORMS

Baker Well Service	—	M-C-N	Eugene Is Blk 126	40	dsl engine	—	—	—	—
Big Chief Drlg Co	Rig 34	Phillips	Eugene Is	60	dsl-elec	Emsco EDA-460	1600	2560	18,000
Brewster-Bartle Drlg Co	Rig 1-A	CATC	W Delta Blk 45	50	dsl engine	"Oilwell" 96	3300	3300	20,000
Humble Oil & Ref Co	Rig 50	Humble	Grand Is Blk 16	45–60	dsl engine	Unit U-40	900	450	10,000
Magnolia-Continental-Newmont	Rig 57	M-C-N	Eugene Is Blk 126	40	dsl engine	Natl 55	920	920	7,500
Nicklos Drlg Co	Rig 19	CATC	W Delta Blk 45	50	dsl engine	Natl 130	1680	1680	17,000
Phillips Petroleum Co	Rig 45	Phillips	Eugene Is Blk 191	80	dsl-elec	Emsco ECC	1250	1250	18,000
Rowan Drlg Co Inc	Rig 8	Humble	Grand Is Blk 16	45–60	dsl engine	Natl 125	2340	1920	18,000
Salt Dome Prod Co	Rig 12	Gulf	Ship Shoal Blk 154	54	dsl engine	Beth Tornado	900	1350	12,000
Southeastern Drlg Corp	—	M-C-N	Eugene Is Blk 128	45	dsl engine	—	—	—	—
The Superior Oil Co of Calif	Rig 27	Superior	W Cameron Blk 71	48	dsl engine	Natl 125	900	900	12,500

*Reported Idle February 1, 1958.

HERE IT IS...
a new 2-DorrClone
Dorrco
D-Sander

—designed especially for hard formation drilling



The new Size 2 Dorrco D-Sander is low in both first cost and operating cost. In addition, it is light in weight and easy to move. Designed especially for hard formation drilling with any rig, or slim hole drilling in a wide variety of formations, it brings the benefits of drilling fluids substantially free of drilled solids within the reach of every operator.

The benefits from using Dorrco D-Sanders are many. In many fields along the Gulf Coast, as well as oth·r areas, abrasive sand can seriously reduce the life of bits and pump parts unless a D-Sander is used. In addition, the high viscosity of mud laden with drilled solids reduces drilling rates as much as 25 per cent.

In these areas, important savings in drilling costs result in that section of the hole where unweighted mud can be used.

But recent experience has proved that savings can also be realized in many other areas where abrasive formations are not encountered. In these areas, "flour sand" Dorrco D-Sanders, set to remove all drilled solids above 30 microns in size, result in greatly improved drilling speeds—sometimes in excess of 15 per cent.

In harder formations, drilling rates are slower and drilled solids are produced at a lower rate. In many of these areas, the Size 2 D-Sander, which provides capacities up to 250 gpm, is entirely adequate, yet it costs less to buy, to move and to operate than larger units.

The new Size 2 D-Sander compliments the capacity ranges of the larger sizes 4 and 6. With this new addition, Swaco offers units suitable for any rig and any drilling condition. Write for full information.

SWACO

SALT WATER CONTROL Inc.

A Sid Richardson Development Company

1211 Ft. Worth National Bank Phone: ED 2-4434 Ft. Worth, Texas

Safeguard Your Operation

with equipment you can trust

Safety and success go hand in hand with Cameron high pressure controls. Our development of the first successful Blowout Preventer set a standard in the industry which has been maintained through 36 years of continuous research and development. As drilling depths increase and destructive pressures become even more critical, you may rely on Cameron's full line of controls to safeguard every phase of your drilling and completion operations.

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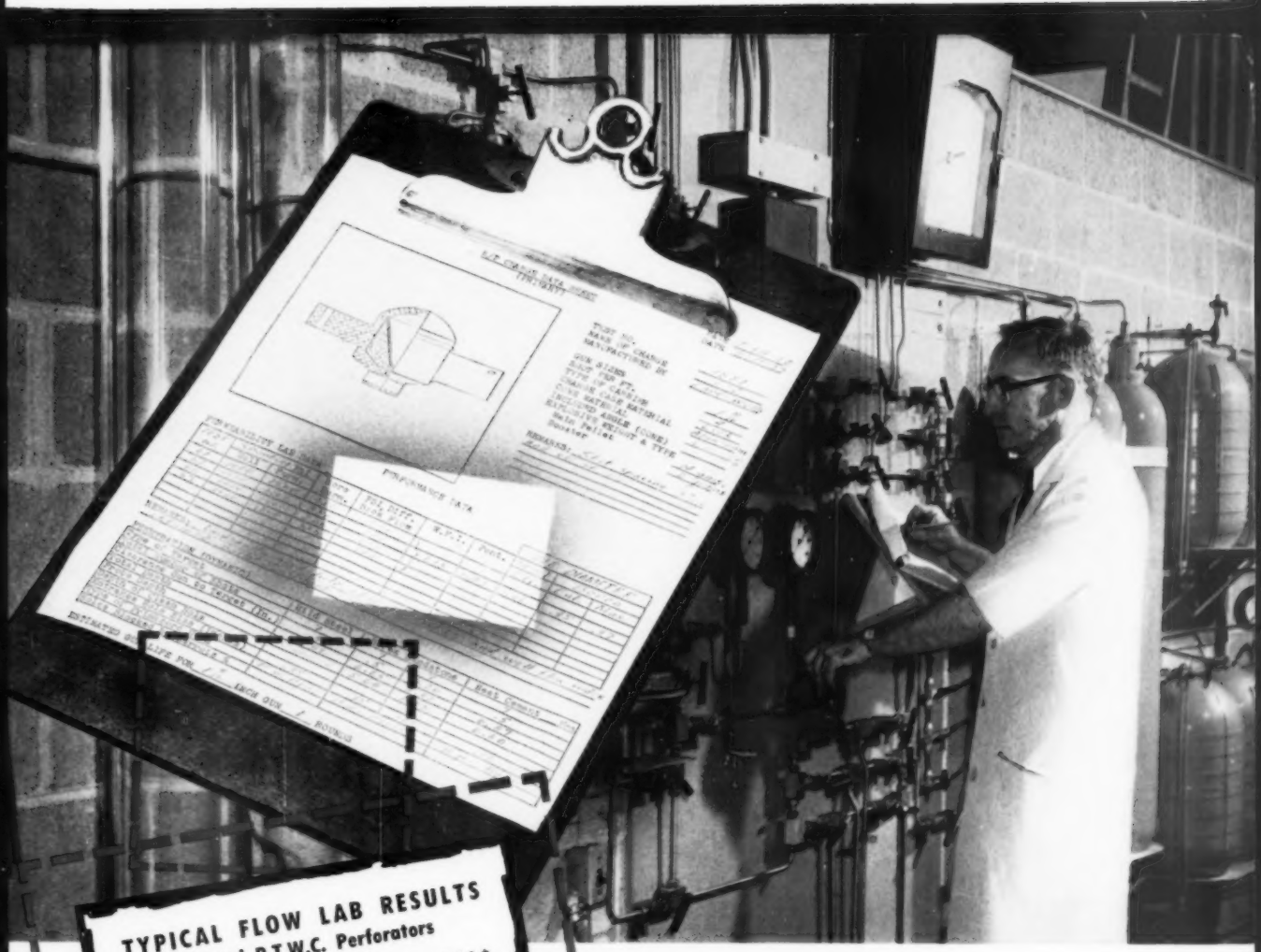

TYPICAL FLOW LAB RESULTS
Selected P.T.W.C. Perforators

Perforators	Average W.F.I.*
1 11/16 Bearcat	1.13
2 3/16 Bearcat	1.06
1 11/16 Swing Jet	.96
1 11/16 Competitor A	.92

*Well Flow Index is the ratio of the flow through the perforated core to the flow through the same core prior to perforating.

Documented PERFORATING PERFORMANCE

FROM THE LABORATORIES OF LANE-WELLS COMES A NEW MEASURE OF PERFORATING EFFECTIVENESS

For more than a year Lane-Wells Flow Laboratory engineers have been testing perforators under pressure and temperature conditions duplicating those found underground . . . accumulating data to help you evaluate perforating. Perforations made under various formation-to-hole pressure differentials in formation samples and the subsequent flow rates provide an index of perforating effectiveness. This WFI (well flow index), together with other accepted perforating performance values, gives you more information than has ever been available before. Ask your Lane-Wells man about this newest Lane-Wells research contribution in the interest of improved petroleum production.

LANE-WELLS COMPANY

P. O. BOX 1664, HOUSTON 1, TEXAS

THE FIRST HUNDRED YEARS

In just a few months, the petroleum industry will note the beginning of its hundredth year from the date of the Drake discovery. From this modest start, the oil business has grown into an empire of energy . . . one of the vital sources of power for the needs of man.

Reviewing the past and previewing the future . . . one of the most important factors contributing to oil's commanding position is research – the continuous investigation to do things better. Halliburton will continue to devote a substantial share of its resources for "the better way."

HALLIBURTON OIL WELL CEMENTING COMPANY

DUNCAN, OKLAHOMA